National Aeronautics and Space Administration
Goddard Earth Science Data Information and Services Center (GES DISC)

NASA CLIMCAPS Level-2 Products User Guide: File Format and Definition

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Version 2.1

Product Version: 2

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Revision History

Document Version	***Software Version***	***Revision Date***	***Changes / Comments***
1	1.03	2019-09-09	Initial Release
2	2.28.02	2019-12	Updated Section 1.9 What's New to add JPSS-1 that was previously missing. Updated document title from Version 1. Added variables: a) Averaging Kernels b) ir_precip_est c) surf_dew_point_temp d) surf_h2o_vap_pres Addressed known issues from version 1: a) MERRA-2 first guess b) surf_emis_mw c) Reported error estimates
2.1	2.39.03		Added Aqua AIRS and AMSU data products Updated document to include Aqua AIRS and AMSU-A throughout Updated references. Added Table B.2.1 to identify differences in the cloud cleared radiance products

Table of Contents

1.0 Introduction

This document provides basic information for using Version 2 Level-2 products from the Community Long-term Infrared Microwave Coupled Atmospheric Product System (CLIMCAPS). The CLIMCAPS algorithm approach is briefly described in Section 2.2 and Appendix A. Users are encouraged to read the Algorithm Theoretical Basis document for algorithm details. [Reference 4]

The products described in this document are derived from Infrared/Microwave (IR/MW) sounder suites:

1) The Cross-track Infrared and Microwave Sounding Suite (CrIMSS) instruments on the Suomi-National Polar-Orbitting Partnership (S-NPP) and NOAA-20 / Joint Polar Satellite System (JPSS-1) satellites.
2) Atmospheric Infrared Sounder (AIRS) and its Advanced Microwave Sounding Unit A (AMSU-A) on the Aqua satellite.

The CrIMSS instrument suite consists of the Cross-track Infrared Sounder (CrIS) infrared sounder and the Advanced Technology Microwave Sounder (ATMS) microwave sounder.

The main CLIMCAPS Level-2 retrieval products contain a variety of geophysical parameters retrieved from IR/MW sounder suites measurements, including profiles of temperature, water vapor and trace gas species as well as clouds and surface properties for six minutes of instrument observation at a time. An additional cloud-cleared radiance product contains estimates of the radiances that would have been observed in the absence of clouds. This cloud cleared radiance product can be valuable in a range of applications and perhaps most importantly as companion to the Level-2 product. All geophysical parameters in the Level-2 file are retrieved from the cloud cleared radiances. CLIMCAPS products have been annotated with both file and variable level attributes to fully describe their contents.

1.1 Overview of Sounder SIPS

The S-NPP / JPSS Sounder SIPS, is one of six SIPSs formed by NASA to provide climate-quality products by processing of level 0 data through level 1, level 2 and level 3 from the Suomi NPP (previously known as NPP) satellite and the NOAA-20 / JPSS-1 satellite. The Sounder SIPS is specifically responsible for producing atmospheric sounding products from the CrIMSS instrument suite and continuity products from the corresponding AIRS/AMSU-A instrument suite on the EOS-Aqua platform.

The S-NPP Sounder SIPS is a team made up of the Jet Propulsion Laboratory (JPL) and the Goddard Earth Sciences Data and Information Services Center (GES DISC). JPL provides the overall project management, science algorithm software integration, test and validation support. The GES DISC performs level 0 data acquisition and routine data processing operations. The GES DISC / Distributed Active Archive Center (DAAC) and distribution of the data products and associated documentation.

1.2 Mission Description

Hyperspectral IR/MW sounder suites use the complementary sensing abilities of hyperspectral IR sounding instruments and MW sounding to retrieve atmospheric conditions. A series of these instrument suites on platforms in similar 1:30 PM sun-synchronous orbits provide information on the atmospheric state for weather prediction and collectively provide a climate record from 2003. Infrared (IR) and microwave (MW) sounders are designed to be used together as IR/MW sounding suites. The retrieval algorithm combines IR data from AIRS or CrIS with MW data from AMSU-A or ATMS in a single IR+MW retrieval.

An atmospheric sounder measures how the physical properties of a column of air vary with altitude. The measurement as a function of altitude is sometimes called a “profile”, a “sounding”, or a “retrieval”. The term "sounder" refers to measuring how the temperature and salinity are similarly measured in the ocean using sound waves. “Retrieval” refers to using a computer algorithm to extract the profile from the measured data.

The hyperspectral IR instruments measure the upwelling spectrum in the infrared emitted from the Earth's surface and absorbed and emitted from the atmosphere's constituents. Each infrared wavelength, or channel in the IR instrument, is sensitive to different atmospheric constituents corresponding to a range of heights in the atmosphere depending on the degree of absorption of that constituent. Temperature profiles are produced by measuring CO_2 absorption features with varying degrees of absorption; channels with little absorption see closer to the surface, while channels with high absorption see higher in the atmosphere. Water vapor profiles use H_2O absorption features in a similar way. The CLIMCAPS retrieval uses an instrument-specific set of channels to create a profile with altitude, or sounding of the atmosphere. This is called a “retrieval.” MW sounding instruments contribute information on precipitation and surface type, and also help with cloud clearing because they see through non-precipitating clouds.

The Aqua satellite was launched on May 4, 2002 into a polar sun-synchronous orbit. You can see the orbital parameters in Table 1.2.1 below. AIRS and AMSU-A are 2 of 6 instruments onboard the Aqua satellite. The other operating instruments are: Clouds and the Earth's Radiant Energy System (CERES), Moderate Resolution Imaging Spectroradiometer (MODIS) and Advanced Microwave Scanning Radiometer – Earth Observing System (AMSR-E). Details about the Aqua Mission can be found at: https://airs.jpl.nasa.gov/

The S-NPP satellite was launched on October 28, 2011 into an orbit with an altitude of 824 km above the Earth surface, an inclination angle of 98.7 deg and a 13:30 local time ascending node. SNPP is the bridge between NASA's Earth Observing System and the Joint Polar Satelite System (JPSS) and is a result of a partnership between NOAA, NASA and the Department of Defense (DoD). SNPP is the first in a series of five next generation U.S. weather satellites of the JPSS. CrIMSS (CrIS and ATMS) are two of the five instruments

onboard the S-NPP satellite. The other instruments are: Clouds and the Earth's Radiant Energy System (CERES), Ozone Mapping and Profiler Suite (OMPS) and Visible Infrared Imaging Radiometer Suite (VIIRS).

The NOAA-20 / JPSS-1 satellite was launched on November 18, 2017 from Vandenburg Air Force Base in California with similar orbital parameters and instruments as S-NPP. It is the second of 5 planned satellites of the JPSS. As is practice with NOAA when a satellite has successfully reached orbit, completed all on-orbit checkouts and is declared 'operational' it is renamed to follow the naming of NOAA satellites. JPSS-1 was renamed to NOAA-20 on May 30, 2018. The satellite will be referred to as JPSS-1 or J1 in this document.

More information about both the S-NPP and JPSS Missions can be found at: https://www.nasa.gov/mission_pages/NPP and https://www.jpss.noaa.gov/, respectively

Table 1.2.1 contains a summary of orbital platform parameters.

Table 1.2.1 Approximate Aqua, S-NPP and JPSS-1 orbital parameters

Platform	Alt (km)	Orbit Incl. (°)	Equator X Time	Period (mins)	Repeat Orbits	Repeat Days	Launch
Aqua	705	98.2	13:30	98.8	233	16	04 May 2002
S-NPP	824	98.7	13:30	101	228	16	28 Oct 2011
NOAA-20 / JPSS-1	824	98.7	13:30	101	228	16	18 Nov 2017

1.3 AIRS Instrument Description

AIRS is a cross-track scanning instrument. A scan mirror rotates around an axis along the line of flight and directs infrared energy from the Earth into the instrument. As the spacecraft moves along, this mirror sweeps the ground creating a scan 'swath' that extends roughly 800 km on either side of the ground track. Between Earth scans, the scan mirror also allows the instrument to view various calibration sources. The scan mirror provides ±49.5° (from nadir) Earth coverage along with views to space and to on-board spectral and radiometric calibration sources every scan cycle. The AIRS scan mirror rotates 360° every 8/3 of a second (2.667 seconds), so that AIRS does three scans for every 8-second AMSU-A scan.

1.4 AMSU-A Instrument Description

AMSU-A, part of the AIRS Project Instrument Suite, is a microwave temperature sounder implemented as two independently operated modules. AMSU-A also measures surface and moisture information. AMSU-A is one of a series of similar instruments. Aerojet (now part of Northrop Grumman) built AMSU-A.

AMSU-A has a total of 15 channels:

- Module 2 (AMSU-A2) has 2 channels (23.8 GHz and 31.4 GHz, numbered 1-2) providing surface and moisture information (total precipitable water and cloud liquid water).
- Module 1 (AMSU-A1) has 12 channels (numbered 3-14) in the 50-58 GHz oxygen absorption band, providing the primary temperature sounding capability.
- Module 1 also has 1 channel at 89 GHz (numbered 15) providing surface and moisture information

Like AIRS, AMSU-A is a cross-track scanner. The three receiving antennas, two for AMSU-A1 and one for AMSU-A2, are parabolic focusing reflectors that rotate to scan.

AMSU-A scans once per 8 seconds, three times more slowly than AIRS. The footprints are approximately three times as large in diameter as those of AIRS (45 km at nadir). This results in three AIRS scans per AMSU-A scan and nine AIRS footprints per AMSU-A footprint.

1.5 AMSU-A status as of 2021:

- channels 3, 8, 10-13, and 15 are working well
- channels 1, 2, 4, and 5 are no longer usable
- channels 6, 7, 9, and 14 function but have noise issues.

In order to be able to process data after the 2016 failure of AMSU-A2, CLIMCAPS Aqua v2 is also processed in an IR-Only mode. See section 2.8.

1.6 CrIS Instrument Description

The Cross-track Infrared Sounder (CrIS) is a Fourier Transform Spectrometer (FTS) which measures interferograms in three Infrared (IR) bands simultaneously. For more instrument details see Reference 1.

The version 2 CLIMCAPS products for SNPP and J1 use version 2 of ATMS and CrIS Level-1B as their primary inputs. CLIMCAPS products for S-NPP were produced using CrIS Level-1B product in both Normal Spectral Resolution (NSR) and Full Spectral Resolution (FSR). CLIMCAPS products for JPSS-1 are produced using the CrIS Level-1B FSR product.

1.6.1 S-NPP CrIS Instrument Resolution

For the first part of the SNPP mission, the effective spectral resolution of CrIS data received from the satellite was lower in the short-wave and mid-wave infrared bands than in the longwave infrared band. Level 0 data received during this initial period is referred to as Normal Spectral Resolution (NSR).

On December 4, 2014, the resolution of the short-wave and mid-wave data transmitted from SNPP was increased to match the long-wave resolution. Level 0 data received from this time through November 2, 2015 is referred to as Full Spectral Resolution (FSR). After the transition to FSR, the effective spectral resolution of short-wave data received on the ground was quadrupled, and the effective spectral resolution of mid-wave data was doubled, with the Level 0 data volume increasing accordingly.

On November 2, 2015, SNPP began transmitting long-wave and short-wave interferograms with extra points on the ends. Level 0 data received from this time onward is referred to as Extended Spectral Resolution (XSR). These points had previously been discarded, but were added to the data stream because it was determined that they could be used to improve the quality of the calibration. [Reference 1]

The CLIMCAPS products for SNPP are produced for NSR and FSR. The FSR dataset begins on November 2, 2015.

1.7 ATMS Instrument Description

ATMS is a 22-channel cross-track scanning microwave sounder providing both temperature and humidity soundings.

The ATMS instrument's Scan Drive Mechanism on S-NPP has been experiencing additional wear on the bearings. To extend the life of the instrument, a decision was made to perform scan reversals for the purpose of 're-wetting' the bearings. The scan reversals are now occurring twice per orbit, starting Aug 9, 2016. The end result of this maneuver is a slight loss of data. This loss of data is represented by the use of Fill Values. [Section 3.8]

1.8 Data Disclaimer

Version 2 CLIMCAPS CrIMSS and AIRS/AMSU-A Level-2 data are released to the public as is. Every effort has been made to properly represent the data which this document describes.

All users are encouraged to read the appropriate documentation listed in the references related to these data products to further understand the contents.

Attention should be given to quality flags and fill values before being used for any analysis or higher processing of the product.

1.9 Where to find the Product

CLIMCAPS Level-2 products can be found at and downloaded from the NASA GES DISC. First time users are asked to register and create an EARTHDATA login account to access the GES DISC collections. There you will find additional information and documentation about this product and other products of interest. The preferred method to locate a data collection is via the unique Digital Object Identifier (DOI) link [see Table 1.6].

Alternatively, users can enter the ShortName directly into the EARTHDATA search string to quickly find CLIMCAPS level 2 products. The data at the GES DISC is organized by unique versioned ShortNames. Also, a general search using the string "CLIMCAPS" under Data Collections will take to you a listing of CLIMCAPS products.

NASA EARTHDATA login: https://disc.gsfc.nasa.gov

Table 1.6. ECS ShortName and DOIs

ECS ShortName	DOI	Title
SNDRSNIML2CCPRETN	10.5067/9HR0XHCH3IGS	Sounder SIPS: Suomi NPP CrIMSS Level 2 CLIMCAPS Normal Spectral Resolution: Atmosphere cloud and surface geophysical state V2
SNDRSNIML2CCPCCRN	10.5067/CNG0ST72533Z	Sounder SIPS: Suomi NPP CrIMSS Level 2 CLIMCAPS Normal Spectral Resolution: Cloud Cleared Radiances V2
SNDRSNIML2CCPRET	10.5067/62SPJFQW5Q9B	Sounder SIPS: Suomi NPP CrIMSS Level 2 CLIMCAPS Full Spectral Resolution: Atmosphere cloud and surface geophysical state V2
SNDRSNIML2CCPCCR	10.5067/ATJX1J10VOMU	Sounder SIPS: Suomi NPP CrIMSS Level 2 CLIMCAPS Full Spectral Resolution: Cloud Cleared Radiances V2
SNDRJ1IML2CCPRET	10.5067/LESQUBLWS18H	Sounder SIPS: JPSS-1 CrIMSS Level 2 CLIMCAPS: Atmosphere cloud and surface geophysical state V2
SNDRJ1IML2CCPCCR	10.5067/KE4WCXM829A3	Sounder SIPS: JPSS-1 CrIMSS Level 2 CLIMCAPS: Cloud Cleared Radiances V2
SNDRAQIML2CCPRET	10.5067/JZMYK5SMYM86	Sounder SIPS: AQUA AIRS IR + MW Level 2 CLIMCAPS : Atmosphere, cloud and surface geophysical state V2

SNDRAQIML2CCPCCR	10.5067/W0OHIT0RAM8O	Sounder SIPS: AQUA AIRS IR + MW Level 2 CLIMCAPS: Cloud Cleared Radiances V2
SNDRAQIL2CCPRET	10.5067/ILFPVBTDHTDL	Sounder SIPS: AQUA AIRS IR-only Level 2 CLIMCAPS : Atmosphere, cloud and surface geophysical state V2
SNDRAQIL2CCPCCR	10.5067/9RRS80QCT0E9	Sounder SIPS: AQUA AIRS IR-only Level 2 CLIMCAPS: Cloud Cleared Radiances V2

1.10 Contact Information

For information, questions or concerns with any of these CLIMCAPS Level-2 data sets, please send to: sounder.sips@jpl.nasa.gov.

For information, questions or concerns with dataset completeness or downloading issues, please send to: gsfc-dl-help-disc@mail.nasa.gov

1.11 References

References 1 - 6 below will take you to a NASA EARTHDATA landing page. To get to the actual document, please click on the 'Documentation' tab from the landing page. If links do not resolve, copy the url into a browser. Also, application user documents are in the works and will be made available alongside the product when ready. The application documents will have more science content about trace gases and go into a little more detail about additional sensors CLIMCAPS supports.

1. NASA SNPP Cross Track Infrared Sounder (CrIS) Level 1B Product Users' Guide https://www.doi.org/10.5067/9NPOTPIPLMAW

2. NASA SNPP Cross Track Infrared Sounder (CrIS) Level 1B Quality Flags Description Document https://www.doi.org/10.5067/9NPOTPIPLMAW

3. NASA Advanced Technology Microwave Sounder (ATMS) Level 1B Data Product User Guide https://www.doi.org/10.5067/HFDD6A30MA10

4. CLIMCAPS Level-2 ATBD Uncertainty Characterization and Propagation in the Community Long-Term Infrared Microwave Combined Atmospheric Product System (CLIMCAPS) https://www.doi.org/10.5067/9HR0XHCH3IGS

5. Test Report of Performance of CLIMCAPS-SNPP and CLIMCAPS-JPSS1 Retrievals https://disc.gsfc.nasa.gov/datasets/SNDRSNIML2CCPRETN_2/summary

6. Version 2 CLIMCAPS-Aqua Retrieval Product Performance Test Report https://www.doi.org/10.5067/JZMYK5SMYM86

7. AIRS on-line Documentation Page: https://disc.gsfc.nasa.gov/information/documents?title=AIRS%20Documentation

8. NetCDF Climate and Forecast (CF) Metadata Conventions, Version 1.6, http://cfconventions.org/cf-conventions/v1.6.0/cf-conventions.html

9. MERRA-2 https://gmao.gsfc.nasa.gov/reanalysis/MERRA-2/

10. Global Modeling and Assimilation Office (GMAO) (2015), MERRA-2 inst3_3d_asm_Nv: 3d,3-Hourly,Instantaneous,Model-Level,Assimilation,Assimilated Meteorological Fields V5.12.4, Greenbelt, MD, USA, Goddard Earth Sciences Data and Information Services Center (GES DISC), doi:10.5067/WWQSXQ8IVFW8

11. NASA Data Processing Levels https://earthdata.nasa.gov/collaborate/open-data-services-and-software/data-information-policy/data-levels

12. AIRS Level-2 Science team Status of CLIMCAPS https://airs.jpl.nasa.gov/system/presentations/files/381_StatusBarnet.pdf .

13. Suomi-NPP: https://www.nasa.gov/mission_pages/NPP

14. Joint Polar Satellite System: https://www.jpss.noaa.gov/

1.12 What's New

The differences between version 2.0 and the earlier version 1.0 are itemized here.

1. Addition of JPSS-1: CrIMSS to the CLIMCAPS product suite.

2. Added the following variables:
   a) Averaging Kernels – an entire subgroup named “ave_kern” with information about retrieval information content for air temperature, H_2O vapor, O_3, CH_4, CO, CO_2, and HNO_3.
   b) ir_precip_est_24hr -- The thickness of a layer of liquid water equivalent to the estimated preciptitation over 24 hours.
   c) surf_dew_point_temp -- near surface_dew-point temeprature
   d) surf_h2o_vap_pres_deficit-- Near-surface water vapor saturation pressure deficit

3. Some known issues from version 1 have been addressed:

a) The MERRA-2 first guess profile had been accidentally overwritten by the GFS forecast file, so that in this 8-month sample run the apriori and all the "fg" variables are actually the GFS forecast interpolated to the time and location of the observation.
b) Erroneous surface microwave emissivity (surf_emis_mw) in V1 CLIMCAPS is corrected.
c) Actual error estimates are now reported for cloud-cleared radiances, rad_*w_err

4. Addition of Aqua: AIRS and AMSU-A to the CLIMCAPS product suite.
   a) CLIMCAPS-Aqua produces an AIRS + AMSU-A product as well as a AIRS-only product.

2.0 Level-2 Product Overview

Level-2 products are created from using both an infrared instrument (AIRS or CrIS) and a microwave instrument (AMSU-A or ATMS) Level-1B observations using the CLIMCAPS algorithm. This algorithm creates a main retrieval product with geophysical parameters and an additional cloud-cleared radiance product. In addition, CLIMCAPS-Aqua produces an infrared-only (AIRS-only) set of products as well. The product file types described in this document are :

1) Level-2 CLIMCAPS Retrieval (L2_CLIMCAPS_RET)
2) Level-2 CLIMCAPS Cloud-Cleared Radiances (L2_CLIMCAPS_CCR)

2.1 Product Granulation and Identification

The Level-2 products are divided into a series of 6-minute segments or granules with each granule making up one file and 240 granules per day. Each file contains all observations for a given type made during a period of exactly 6 minutes. For each day, each 240 files are identified by granule number in the filename. For example, **g156** for granule 156 out of 240. See Figure 4 to see how the granules for a given day map to the globe.

The nominal start time of granule 1 of each day for CrIMSS is defined to be T00:00:00Z. Because both CrIS and ATMS instruments are synced to TAI93, the start time of the first 8-second scanset of a day can be anywhere up to 8 seconds later. It moves 1 second with each leap second. If the first scanset starts 8 seconds after the nominal start time, then the data can extend up to 8 seconds past the nominal end time. AIRS/AMSU-A granules are permanently synchronized to the start of year 1956, so the actual start time of granule 1 of a given day is about five and half minutes into the day, with the exact time depending on how many leap seconds there have been. In 2002 the start times for granule 1 is T00:05:26Z, and by January 2021 it is T00:05:21Z.

The ability to uniquely identify a granule is built in to the Level-1B and Level-2 products. This is extremely useful when publishing analysis results. The nominal time coverage, represented as a string: yyyymmddThhmm, is used to construct a unique granule identifier called “gran_id”. gran_id is stored as a global attribute that is also used in the filename, see section 2.6 File Naming Convention.

In addition, there is an observation identifier variable called “obs_id” that can further uniquely identify an observation within the granule. The obs_id is formatted as the gran_id with observation information appended to it. Because of the different viewing geometry, AIRS, AMSU-A, ATMS and CrIS obs_ids differ. Level-2 CLIMCAPS obs_ids follow the AMSU-A/CrIS pattern because their retrieval is done in units of FORs, corresponding to AMSU-A or CrIS geometry.

The format of AIRS and ATMS obs_id is: yyyymmddThhmm.aaaExx where 'aaa' is the 3-digit along-track index (001 – 135) and xx is the cross-track index (01-90 for AIRS, 01 – 96 for ATMS). The "E" indicates earth view.

For example:

20160125T1300.001E18

CrIS/AMSU-A/Level-2 obs_id: Each field of regard (FOR), defined as a set of 9 simultaneously observed fields of views (FOV), has a globally unique ID stored in the variable "obs_id". The observation ID is created from the granule ID, with information appended to identify the FOR observation within the granule.

The dimensions of this variable (atrack=45, xtrack=30) correspond to the first two dimensions of the science data variables, such as radiances. An observation ID can be associated with data by applying the same indices into these common dimensions.

The format of the CrIS/AMSU-A/Level-2 observation ID string is "yyyymmddThhmm.aaExx", where "aa" is the 2- digit along-track index (01-45), and "xx" is the 2-digit cross-track index (01-30). The "E" indicates that it is an earth view.

For example:

20160125T1300.01E18

FOV Observation ID: At the finest level of granularity, each FOV within a FOR observation has a globally unique ID that is stored in a variable called "fov_obs_id". The FOV observation ID is created from the observation ID, with extra information appended to identify the FOV within the FOR observation.

The dimensions of this variable (atrack=45, xtrack=30, fov=9) correspond to the first three dimensions of the science data variables, such as radiances. A FOV observation ID can be associated with data by applying the same indices into these common dimensions.

The format of the FOV observation ID string is "yyyymmddThhmm.aaExx.f" where "f" is the 1-digit FOV number (1-9).

For example:

20160125T1300.01E18.6

2.2 Algorithm Background

The Sounder SIPS Level-2 data products are a product of processing NASA Level 0 data through Level 1A, Level 1B, and Level-2. For a definition of the NASA Data Processing Levels please see reference 8 or go to: NASA Processing Levels

The CLIMCAPS retrieval approach is based on the AIRS Level-2 science team algorithm design [AIRS Documentation], employing many of the same components as the AIRS V7 algorithm, such as cloud clearing, channel sub-setting, sequential optimal estimation and scene-specific information content analysis. Two significant departures are that CLIMCAPS:

(i) replaces the AIRS V7 first guess, namely the SCCNN neural net statistical retrieval, with MERRA2 as a-priori [Reference 8] (doi:10.5067/WWQSXQ8IVFW8)

(ii) ingests and propagates two-dimensional error covariance matrices for a full accounting of algorithm, measurement and atmospheric state uncertainty. [Reference 10]

Technical details of the Level-2 processing steps and calibrations can be found in the Algorithm Theoretical Basis Document (ATBD). [Reference 4]

2.3 Data Organization

The Level-2 products are divided into a series of 6-minute segments with one segment per file. Each file contains all observations of a given type made during a period of exactly 6 minutes. For each day there are 240 files (also known as granules), identified by granule number in the filename: g021 is granule 21 out of 240. For granule start time details, refer to section 2.1.

2.4 File Format and Structure

The files are in Network Common Data Form, version 4 (netCDF4/HDF5) format.

The product format takes advantage of the netCDF4 data model and makes use of groups, dimensions, variables and attributes to fully describe the science data. See section 3.0 Data Content for a listing of key dimensions and attributes.

2.5 Metadata

Every effort has been made to ensure that metadata conforms to the Climate and Forecasting (CF), Version 1.6, and Attribute Conventions for Data Discovery (ACDD), Version 1.3, guidelines.

See the full product specifications in Appendix B.

For more information on CF, refer to: http://cfconventions.org/

For more information on ACDD, refer to:
http://wiki.esipfed.org/index.php?title=Category:Attribute_Conventions_Dataset_Discovery

2.6 File Naming Convention

File naming for Sounder SIPS products will be unique and include the following tokens separated by the delimiter '.'

<Sounder_SIPS_ID>.<platform>.<inst_ID>.<gran_ID>.<product_granularity>.<granule_number>.<product_type>.<variant>.<version>.<production_location>.<prod_timestamp>.<extension>

SNDR.*satellite.instrument_id.yyyymmdd*T*hhmm*.m06.g101.L2_CLIMCAPS_RET_NSR.std.v*mm_mm*.G.*yymmddhhmmss*.nc
SNDR.*platform.inst_id.yyyymmdd*T*hhmm*.m06.g101.L2_CLIMCAPS_RET_NSR.std.v*mm_mm*.G.*yymmddhhmmss*.nc

Where:

- platform = SNPP, JPSS1, AQUA
- inst_ID = CRIMSS, AIRS or AIRS_IM ("IM" meaning IR+MW is used for AIRS + AMSU-A)
- gran_ID = Unique granule identifier yyyymmddThhmm of granule start, including year, month, day, hour, and minute of granule start time
- product_granularity = m06 (6 minute)
- granule_number = g###
    - The granule number in the day (001-240)
- product_type <product_type_name_id>
    - L2_CLIMCAPS_RET for CLIMCAPS geophysical retrieved products derived from CrIS FSR spectral resolution.
    - L2_CLIMCAPS_CCR for CLIMCAPS cloud-cleared radiances at FSR spectral resolution.
    - L2_CLIMCAPS_RET_NSR for CLIMCAPS geophysical retrieved products derived from CrIS NSR spectral resolution.
    - L2_CLIMCAPS_CCR_NSR for CLIMCAPS cloud-cleared radiances at NSR spectral resolution.
- variant = std
- version = vmm_mm - eg. v02_39
    - Versioning will be synchronized across Sounder SIPS products
    - Version 2 Level-2 products are derived from version 2 Level-1B products
- production_location = G
    - "G" for Sounder SIPS at GES DISC - Operations
    - "J" for Sounder SIPS at JPL
    - "T" for a test data set
- prod_timestamp in the form yymmddhhmmss)
    - This field is designed to ensure LocalGranuleIDs are unique, even when the same software is used to reprocess the same data.
- Extension (.nc)

Example Filename: 6-minute CLIMCAPS/S-NPP CrIMSS Level-2 NSR granule and CLIMCAPS-Aqua AIRS + AMSU-A respectively.

SNDR.SNPP.CRIMSS.20160114T1000.m06.g101.L2_CLIMCAPS_RET_NSR.std.v02_04.G.180110183539.nc
SNDR.AQUA.AIRS_IM.20160114T2359.m06.g240.L2_CLIMCAPS_RET.std.v02_39.G.201104032757.nc

2.7 Time Representation

Times in the Level-2 products are generally represented as UTC. However, observation times are provided in both UTC and TAI93 representations as a convenience to users.

Coordinated Universal Time (UTC) is the international standard for representation of time. UTC times are expressed in human-readable form, as a set of values indicating year, month, day, hour and so on. In the data stream received from the satellite, observation times are represented as UTC.

Timestamps in product filenames and attributes are represented as UTC and formatted according to the "ISO 8601:2004" standard. For example, the time January 25, 2016 at 13:00 may be represented as either of the following:

2016-01-25T13:00Z (long)
20160125T1300 (compact)

The longer form is used in attributes, and the more compact form is used in filenames. The character "Z" indicates "Zulu time", or UTC.

International Atomic Time (TAI) is expressed as number of seconds elapsed on the surface of the Earth since some reference UTC time. The term "TAI93" indicates that the reference time is the beginning of the year 1993, or 1993-01-01T00:00:00Z. This reference time was chosen to be consistent with data products from other instruments, and to allow for precise representation of times spanning the expected mission length.

2.8 Data Holdings

For the initial release of version 1 CLIMCAPS, a test data set of 8 months was provided. Version 1 covered the months of January, April, July and October of the years 2013 and 2015. The dataset was designed to allow research and comparisons over a full seasonal cycle and comparisons of different phases of the ENSO cycle.

Version 2 of CLIMCAPS Level 2 collection will include the following data sets:

a) SNPP NSR data from January 20, 2012 to present
b) SNPP FSR from Nov 2, 2015 to present
c) JPSS-1/NOAA-20 from Feb 17, 2018 to present

d) Aqua AIRS+AMSU-A from August 30, 2002 to Sept 24, 2016
e) Aqua AIRS-only from August 30, 2002 to present

Note that because CLIMCAPS uses MERRA-2 as a background, the forward processing stream will always be about one month behind the present date.

3.0 Data Content

The Level-2 data products are written in netCDF4 format and therefore make use of groups, dimensions, variables and attributes (global & variable). Every netCDF4 file contains, at a minimum, one root group which is unnamed. If a variable or attribute pertain to a specific instrument or satellite, it will be called out at the end of the description in parentheses, ( ).

Attention should be given to quality flags and checked for fill values before being used for any analysis or higher processing of the product.

A full profile of the contents of the files is included in Appendix B.

Selected fields are highlighted in this section.

3.1 Dimensions

Key dimensions for CLIMCAPS Level-2 RET and CCR products. Note the different dimension values in Table 3.2 for SNPP NSR & FSR.

Table 3.1 Key RET Dimensions

Name	Size	Description
atrack	45	along-track spatial dimension
xtrack	30	cross-track spatial dimension
fov	9	Field-of-view dimension
air_pres	100	Fine atmospheric pressure levels for temperature and most gases
air_pres_h2o	66	Fine atmospheric pressure levels for water-vapor variables

Table 3.2 Key CCR Dimensions

Name	Size	Description
atrack	45	along-track spatial dimension
xtrack	30	cross-track spatial dimension
wnum_lw	717	longwave IR channel number
wnum	2378	IR channel number (AIRS)
wnum_mw	437	midwave IR channel number (SNPP NSR)
	869	midwave IR channel number (SNPP FSR and JPSS-1)

wnum_sw	163	shortwave IR channel number (SNPP NSR)
	637	shortwave IR channel number (SNPP SFR and JPSS-1)

3.2 Global Attributes

There are two types of attributes: global & variable. In this section we will talk about global attributes. Global attributes, sometimes referred to as 'file-level attributes', provide information about the entire file or 6-minute granule. This includes observation times, publisher and creator information, data provenance, and location information. Many attributes are required to conform to the CF & ACDD standards while other attributes are written for consistency with legacy products.

A full definition of the global attributes can be found in Appendix B.

Table 3.2.2 Key Global Attributes

Name	Description
date_created	The date on which this version of the data was created
geospatial_lat_min	The southernmost latitude covered by the dataset
geospatial_lat_max	The northernmost latitude covered by the dataset
geospatial_lon_min	The westernmost longitude covered by the dataset. See also geospatial_lon_max.
geospatial_lon_max	The easternmost longitude covered by the dataset. Cases where geospatial_lon_min is greater than geospatial_lon_max indicate the bounding box extends from geospatial_lon_max, through the longitude range discontinuity at the antimeridian, to geospatial_lon_min; for example, geospatial_lon_min=170 and geospatial_lon_max=-175 incorporates 15 degrees of longitude (ranges 170 to 180 and -180 to -175).
geospatial_lat_mid	granule center latitude
geospatial_lon_mid	granule center longitude
geospatial_bounds	Describes the data's 2D or 3D geospatial extent in Open Geospatial Consortium's (OGC) Well-Known Text (WKT) Geometry format. Longitude values are limited to the (-180, 180) range. Example: 'POLYGON ((40.26 -111.29, 41.26 -111.29, 41.26 -110.29, 40.26 -110.29, 40.26 -111.29))'.
product_name_granule_number	zero-padded string for granule number of day (g001-g240)
gran_id	Unique granule identifier yyyymmddThhmm of granule start, including year, month, day, hour, and minute of granule start time
identifier_product_doi	digital object identifier (DOI); digital signature

AutomaticQualityFlag	"Passed": the granule contains a non-degraded retrieved value for at least one value in a geolocated FOV; "Suspect": the granule does not qualify as "Passed" but contains a (possibly degraded) retrieved value (possibly without associated geolocation); "Failed": the granule contains no retrieved values.
qa_no_data	A simple indicator of whether this is an "empty" granule with no data from the instrument. "TRUE" or "FALSE".

3.3 Variable Attributes

Each variable has its own associated attributes. Variable attributes are a CF standard and are used to describe the variable in more detail to properly interpret its value.

Table 3.3: Variable Attributes

Attribute	Description
units	units, for variables that represent physical quantities
_FillValue	a single sentinel value indicating the data point contains fill instead of valid data
standard_name	standard name from the CF standard name table, if one exists for the quantity being represented
long_name	a longer name describing the quantity being represented, suitable for a plot title
description	a longer description of the quantity being represented
valid_range	a pair of values indicating the minimum and maximum values to be considered valid
coordinates	a space-separated list of the names of other variables that are coordinates for this variable
coverage_content_type	ACDD/ISO field categorizing types of data: • image • thematicClassification • physicalMeasurement • auxillaryInformation • coordinate • modelResult • qualityInformation • referenceInformation MD_CoverageContentTypeCode
ancillary_variables	a space-separated list of the names of other variables that contain information about this variable
bounds	defines the extent, for cell variables
cell_methods	describes statistical methods used to derive data, for cell variables
flag_values	These attributes collectively tell how to interpret flag variables. See the CF standard for details. In these Level-2 products, these attributes are mostly used in association with the *_qc QC ancillary variables.
flag_meanings	
flag_masks	

AIRS_HDF_name	For users of AIRS retrieval products, this attribute gives the name of the most similar field in the AIRS HDF-EOS products. (Aqua)
AIRS_name	For users of AIRS retrieval products, this attribute gives the name of the most similar field in the AIRS HDF-EOS products. (SNPP / JPSS-1)

3.4 Group Structure

One feature which was added to netCDF4 is the ability to structure files with "groups", which are similar to a directory hierarchy. SounderCDF files are designed so that all of the most commonly needed information is contained in "/", the root group. Subgroups contain more specialized information. Appendix B has a complete list of all the variables contained in each of the groups.

Table 3.4 netCDF4 Groups for retrieval files

Group	Purpose
/ (root)	Main group, with temperature and water vapor profiles, along with supporting location and quality information
/mw	Results from the Microwave-Only retrieval step (does not exist in the Aqua AIRS-only product)
/mol_lay	Retrieved values of water vapor and other gases in units of molecules per square meter per layer -- the SI equivalent of the "column density" used in the SARTA forward model
/aux	Supporting information primarily for the algorithm developers
/ave_kern	Averaging kernels

Table 3.4 netCDF4 Groups for cloud-cleared radiance files

Group	Purpose
/ (root)	Main group, with cloud-cleared spectra, along with supporting location and quality information
/aux_l2	Supporting information about the Level-2 retrieval primarily for the algorithm developers

3.5 Geolocation

Geolocation parameters are used for determining location of each observation on Earth and associated information about that location.

Geolocation variables are located in the file at the root level. These include latitudes and longitudes associated with each observation, as well as satellite and solar geometry information, spacecraft position and orbital characteristics, surface information and related metadata.

These products come from retrieval algorithms that do a cloud-clearing on a Field-of-Regard (FOR) made up of 9 Fields-of-View (FOVs). In this retrieval it is assumed that most geophysical parameters are constant over the area of a FOR, and these are provided at FOR spatial resolution (45 x 30). For some variables, including some cloud quantities, information is available at FOV spatial resolution (45 x 30 x 9). The product contains two sets of location information: {lat, lon, land_frac, ...} provide information about the larger FOR while {fov_lat, fov_lon, fov_land_frac, …} provide information about the smaller FOV. The "coordinates" variable attribute attached to each geophysical field specifies which set of latitude and longitude is appropriate.

Table 3.5.1 Geolocation Dimensions

Dimension name	Size	Meaning
atrack	45	Along-track FOR horizontal dimension
xtrack	30	Cross-track FOR horizontal dimension
fov	9	CrIS FOV dimension within FOR
fov_poly	8	latitude/longitude points defining the polygon bounding an fov (anticlockwise as viewed from above)

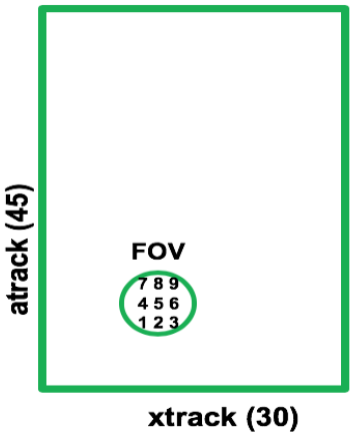


Figure 1. geolocation horizontal dimensions

The key geolocation variables are:

Table 3.5.2 Key FOR Geolocation Variables

Geolocation Variable	Dimensions	Meaning
lat	atrack, xtrack	latitude of FOR center
lon	atrack, xtrack	longitude of FOR center
lat_bnds	atrack, xtrack, fov_poly	latitude of FOR bounding polygon
lon_bnds	atrack, xtrack, fov_poly	longitude of FOR bounding polygon
land_frac	atrack, xtrack	Land fraction over the FOR
surf_alt	atrack, xtrack	mean surface altitude WRT Earth model over FOR
obs_time_tai93	atrack, xtrack	earth view observation midtime for each fov in units of seconds since 1993-01-01T00:00:00
obs_time_utc	atrack, xtrack, utc_tuple	UTC earth view observation time as an array of integers: year, month, day, hour, minute, second, millisecond, microsecond

Corresponding variables fov_lat, fov_lon, fov_lat_bnds, fov_lon_bnds, fov_land_frac, fov_surf_alt provide information at the FOV spatial resolution.

Full geolocation includes information about solar geometry (sol_zen, sol_azi, sun_glint_dist), viewing geometry (sat_zen, sat_azi, view_ang, sat_range, subsat_lat, …) and orbital parameters. See Appendix B for full specification.

One key feature is boundaries. Each FOR and FOV has a bounding 8-point polygon in variables {lat_bnds, lon_bnds} and {fov_lat_bnds, fov_lon_bnds}. This makes it easy to place values in appropriate regions on a map, including the distorted shapes of FOVs and FORs at the edges of the swath. See Figure 2 for an example image using {fov_lat_bnds, fov_lon_bnds} and Figure 5 for an example image using {lat_bnds, lon_bnds}.

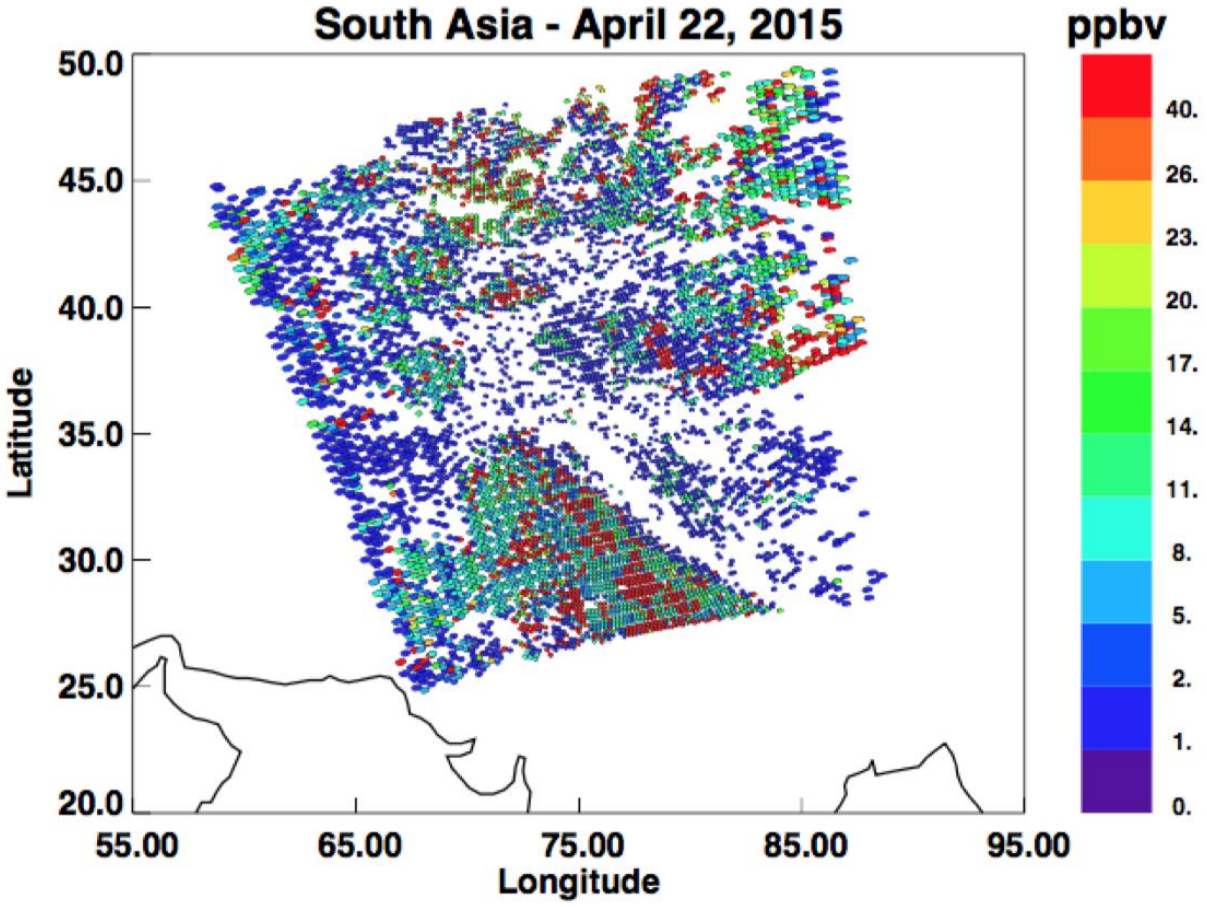


Figure 2. Sample plot of retrieved CrIS NH_3 using FOV bounding polygons. Credit: Karen Cady-Pereira.

3.6 Science Data Variables

These retrievals provide information on a wide variety of geophysical parameters, including temperature, water vapor, constituents, clouds, and surface parameters. This results in a large number of science data variables.

Many variables have associated quality control and error estimate information. These are contained in variables with the same name but with "_qc" and "_err" appended. For example the air temperature profile is contained in a variable named "air_temp"; its error estimate is in "air_temp_err" and its quality control is "air_temp_qc". The "ancillary_variables" variable attribute of air_temp lists "air_temp_qc, air_temp_err". In the tables below the ancillary variables are not listed explicitly. They are indicated in the "ancillary variables" column.

3.6.1 Retrieval Product Science Data Variables

Key retrieval product science data fields are defined below and are found in the /(root) group. See Appendix B for a full listing.

Table 3.6.1 Key CLIMCAPS RET Science Data Variables

Name	Dimensions	Description	Units	Ancillary Variables
air_temp	atrack, xtrack, air_pres	air temperature profile	Kelvin	err, qc
surf_air_temp	atrack, xtrack	near-surface air temperature (~2 meters above surface)	Kelvin	err, qc
h2o_vap_tot	atrack, xtrack	total precipitable water vapor	kg / m2	err, qc
spec_hum	atrack, xtrack, air_pres_h2o	mass fraction of water vapor in moist air	kg / kg	err, qc
surf_spec_hum	atrack, xtrack	Near-surface mass fraction of water vapor in moist air	kg / kg	err, qc
rel_hum	atrack, xtrack, air_pres_h2o	relative humidity over equilibrium phase	unitless	err, qc
surf_rel_hum	atrack, xtrack	relative humidity near the surface over equilibrium phase	unitless	err, qc
gp_hgt	atrack, xtrack, air_pres	Geopotential is the sum of the specific gravitational potential energy relative to the geoid and the specific centripetal potential energy. Geopotential height	m	err, qc

		is the geopotential divided by the standard acceleration due to gravity.		
surf_gp_hgt	atrack, xtrack	geopotential height at the surface	m	err, qc
o3_tot	atrack, xtrack	Total column ozone. (Multiply by 4.670e5 to convert to Dobson Units from kg m^-2)	kg m-2	err, qc
o3_mmr	atrack, xtrack, air_pres	ozone mass mixing ratio to dry air	kg / kg	err, qc
co_mmr_midtrop	atrack, xtrack	Carbon monoxide mass mixing ratio to dry air at 50000 Pa, near the peak of sensitivity	kg / kg	err, qc
ch4_mmr_midtrop	atrack, xtrack	Methane mass mixing ratio to dry air at 40000 Pa, near the peak of sensitivity	kg / kg	err, qc
h2o_liq_tot	atrack, xtrack	total column cloud liquid water	kg m-2	err, qc
h2o_liq_mol_lay	atrack, xtrack, air_pres_lay	cloud liquid water layer total	unitless	err, qc
cld_frac	atrack, xtrack, fov, cld_lay	effective cloud fraction	unitless	err, qc
cld_top_pres	atrack, xtrack, fov, cld_lay	cloud top pressure in order of increasing pressure	Pa	err, qc
cld_top_temp	atrack, xtrack, fov, cld_lay	cloud top temperature	Kelvin	err, qc
num_cld	atrack, xtrack, fov	Number of cloud layers with nonzero cloud fraction	unitless	
tpause_gp_hgt	atrack, xtrack	tropopause geopotential height, where tropopause is determined according to the WMO definition	m	qc
tpause_pres	atrack, xtrack	tropopause pressure, where tropopause is determined according to the WMO definition	Pa	qc
tpause_temp	atrack, xtrack	tropopause temperature, where tropopause is determined according to the WMO definition	Kelvin	qc

surf_freq_mw	surf_freq_mw	Microwave surface emissivity frequencies (hinge points)	Hz	

3.6.2 Cloud-Cleared Radiance Product Science Data Variables

Key cloud-cleared radiance product science data fields are defined in the tables below and are found in the /(root) group. See Appendix B for a full listing. Because of the differences between the CrIS and AIRS instruments, these products differ where the retrieved products don't. Following the Level-1B model, CrIS CCR has separate variables for the longwave, midwave, and shortwave for both the radiances and the NEdN, where AIRS has only a single variable for the whole spectrum. Also CrIS has different NEdN for each of the 9 FOVs, and this information is preserved in the CCR product, even though the CCR combines information from the 9 FOVs to get a single CCR spectrum per FOR.

Table 3.6.2 Key CLIMCAPS CrIMSS CCR Science Data Variables

Name	Dimensions	Description	Units	Ancillary Variables
rad_lw	atrack, xtrack, wnum_lw	longwave clear spectral radiance	mW/(m2 sr cm-1)	err, qc
rad_mw	atrack, xtrack, wnum_mw	midwave clear spectral radiance	mW/(m2 sr cm-1)	err, qc
rad_sw	atrack, xtrack, wnum_sw	shortwave clear spectral radiance	mW/(m2 sr cm-1)	err, qc
nedn_lw	fov, wnum_lw	longwave noise equivalent differential radiance	mW/(m2 sr cm-1)	
nedn_mw	fov, wnum_mw	midwave noise equivalent differential radiance	mW/(m2 sr cm-1)	
nedn_sw	fov, wnum_sw	shortwave noise equivalent differential radiance	mW/(m2 sr cm-1)	

Table 3.6.3 Key CLIMCAPS AIRS CCR Science Data Variables

Name	Dimensions	Description	Units	Ancillary Variables
rad	atrack, xtrack, wnum	clear spectral radiance	mW/(m2 sr cm-1)	err, qc
nedn	wnum	noise equivalent differential radiance	mW/(m2 sr cm-1)	

3.7 Quality Information

For most retrieved geophysical variables, a numerical error estimate in the same physical units is provided in a corresponding ancillary_variable with a name ending in "_err". There are also Quality Control (QC) scores of {0, 1, 2} in corresponding ancillary_variables with a name ending in "_qc".

Table: 3.7.1 *_qc Values

Value	Meaning
0	Highest quality – use without reservation
1	Good quality – suitable for most purposes
2	Do not use. In some cases a physical value is present but is not considered reliable. In other cases only fill values are present.

While CLIMCAPS products have this structure, the philosophy of setting individual values is as follows: CLIMCAPS defines an entire FOR retrieval as good or bad and sets all levels of all variables collectively to 0 or 2. CLIMCAPS, therefore, does not have quality control scores tailored to individual retrieval variables but tags all variables for a target FOR as 0, 1 or 2 based on a fixed set of criteria.

In addition to the _qc and _err variables, there are other indicators of quality. *_dof are degrees-of-freedom for retrievals of individual quantities (air_temp_dof, h2o_vap_dof, o3_dof, ….). In the /aux subgroup there are more detailed internal quality indicators including cloud-clearing noise amplification factors and Chi-squared.

3.8 Missing Data / Fill Values

Fill values are used where there is no valid data, including profiles level with pressures greater than the surface pressure. The fill value is indicated by the attribute '_FillValue'. It is advised to check the data for fill values before it is used. The fill values per variable datatype are listed in the table below.

Table: 3.8.1 Fill Values

Variable Type	Fill Value
unsigned 8-bit integer	255UB
unsigned 16-bit integer	65535US
unsigned 32-bit integer	4294967295U
floating point	9.96921e+36

3.9 Key supporting information variables for profiles

These variables provide supporting information to interpret the science variables.

Name	Dimensions	Description	Units
air_pres	air_pres	pressure levels	Pa
air_pres_h2o	air_pres_h2o	H2O vapor pressure levels	Pa
air_pres_lay	air_pres_lay	pressure at the middle of each layer	Pa
air_pres_lay_bnds	air_pres_lay, bnds_1d	Min and max pressure of each layer	Pa
air_pres_nsurf	atrack, xtrack	Index in air_pres of the level at the surface. Values at levels beyond this are invalid, representing data below the Earth's surface.	unitless
air_pres_h2o_nsurf	atrack, xtrack	Index in air_pres_h2o of the level at the surface. Values at levels beyond this are invalid, representing data below the Earth's surface.	unitless
air_pres_lay_nsurf	atrack, xtrack	Index in air_pres_lay of the layer at the surface. Values for layers beyond this are invalid, representing data below the Earth's surface.	unitless

3.10 Vertical profile representation of gases

CLIMCAPS retrieves all gases as vertical profiles on 100 fixed-pressure layers to satisfy internal requirement for radiative transfer calculations. The 100-layer gas retrievals are preserved in the "mol_lay" subgroup, even though CrIMSS measurements do not have information content for all 100 layers. We do this for two reasons, (i) support radiative transfer calculations with CLIMCAPS retrievals and (ii) allow data users to calculate integrated column densities that are specifically targeted to their applications.

For the products in the root group, water vapor and ozone are reported on the 100 fixed-pressure levels which bound the layers. For water vapor, levels at pressures under 5153 Pa (51.53 hPa) are not reported.

For gases CO and CH_4, where there is less than a single degree of freedom, we report MMR only at a single pressure level near the peak of the retrieval sensitivity: 40000 Pa for CH_4, and 50000 Pa for CO.

Pressure levels below the surface are always filled with fill values.

Level concentrations of gases are estimated from the layer gas amounts. CLIMCAPS, using a direct interpolation, preserves information from MERRA2 along with the information from the retrieval.

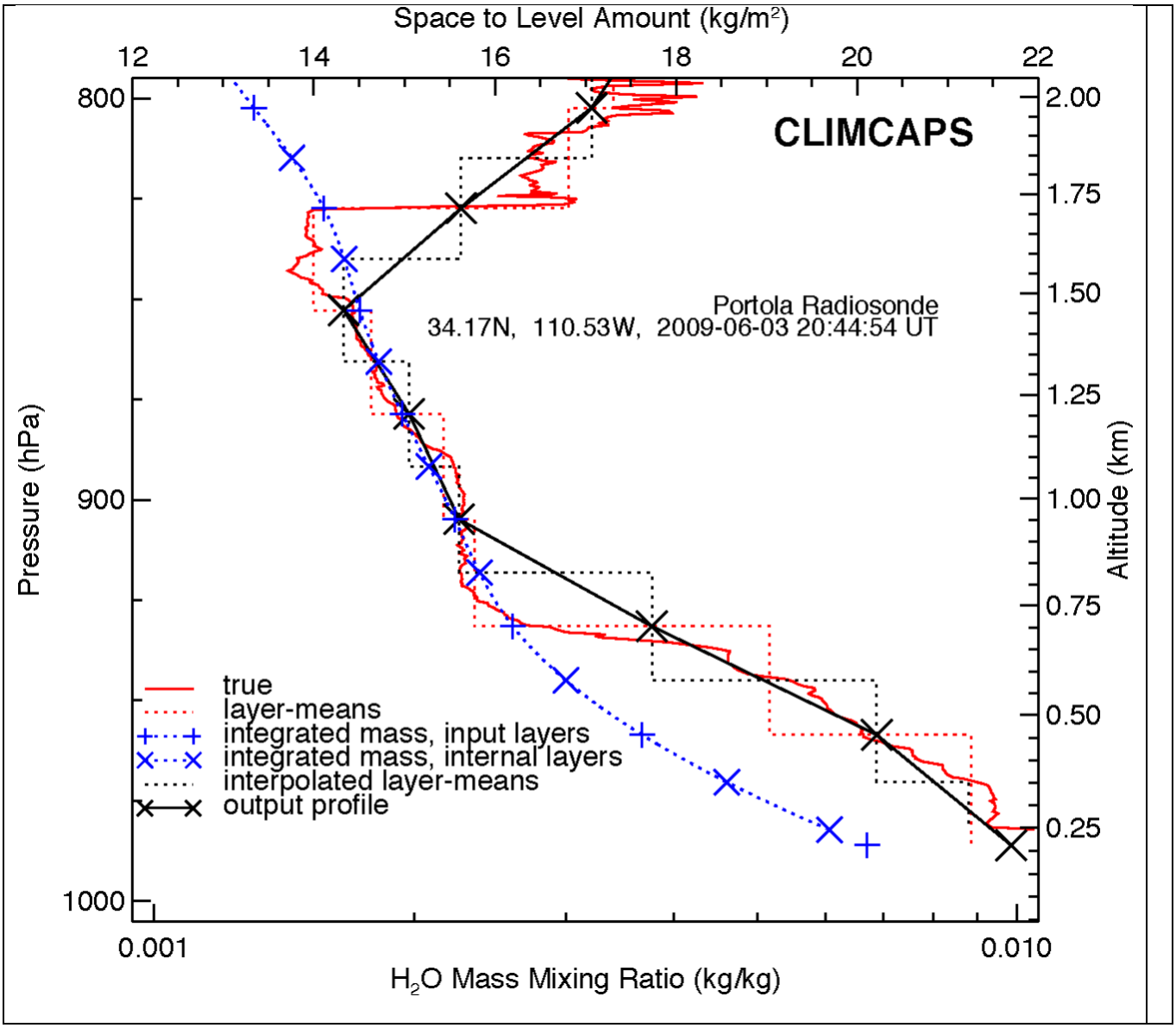


Figure 3. Water vapor level concentration for CLIMCAPS.

For CLIMCAPS, level concentrations of gases are estimated from layer-amounts using the mean-value theorem and assuming that layers with boundaries at

$$P_{\text{bnd}} = {}^{P_i - P_{i-1}}/_{\ln P_i - \ln P_{i-1}}$$

have mean values which estimate the profile at the levels P_i. Layer-mean mixing ratios are uniquely specified by the layer amounts, the temperature profile and pressure differences through the hydrostatic and hypsometric equations [Wallace and Hobbs, 1977, pgs. 53-54].

Figure 3 illustrates the procedure. A true radiosonde profile of water vapor mixing ratio is converted to layer amounts as would be produced by the CLIMCAPS algorithm. These are shown in the figure as mean mass mixing ratio, which is obtained by dividing the layer water vapor amount by the layer dry air amount. The amounts in each layer are summed from top to bottom to produce a piecewise linear profile of top-to-level integrated amount. The integrated amount is then interpolated to a new set of levels, P_{bnd}, and differenced to produce a new set of layer amount. Similarly, the dry-air top-to-level integrated amounts are interpolated to the new levels, and mean mixing ratios (ratio of gas amount to dry-air amount) are assumed to be the mixing ratio at the levels P_i. Values at the end points are linearly extrapolated from the profile at interior points. The reported profiles have errors from the interpolations and use of the mean value theorem[1]. The algorithm uses linear interpolation in log pressure and top-to-level amount which introduces larger errors when top-to-level amount second derivative is large; these errors are not included in mixing ratio error estimates.

Error estimates for the level mixing ratios are interpolated from the fractional layer-amount errors. Fractional error is assumed to be fully correlated and linearly interpolated in log pressure from the arithmetic mean pressures of each level (uncorrelated error involves linearly interpolating variance).

3.11 Known issues

In rare cases (~1 per day) water vapor fields can be zero or even negative while the corresponding *_qc quality field indicates usable quality (0 or 1). For applications where this is not acceptable, users should apply a minimum and either substitute the minimum value to the affected levels or reject the entire profile.

The fields that can be slightly negative, zero, or unrealistically dry are spec_hum and rel_hum. In addition, fields mol_lay/h2o_vap_mol_lay and aux/fg_h2o_vap_mol_lay can be zero or unphysically low, but never negative.

Reported error estimates are all fill values for:

a) [surf_]spec_hum_sat_[ice|liq]_err
b) [surf_]gp_hgt_err

[1] The mean value theorem says that some point in the interval has the mean value, but not where the point is located.

c) h2o_liq_mol_lay_err
d) mw_[surf_]air_temp_err
e) mw_surf_temp_err
f) surf_ir_emis_err, cld_frac_err, cld_top_pres_err, for_cld_frac_tot_err, for_cld_top_pres_tot_err, for_cld_frac_2lay_err, for_cld_top_pres_2lay_err, h2o_liq_tot_err

4.0 Options for Reading the Data

The product files are written in netCDF4/HDF5. Because netCDF4 builds upon the classic netCDF data model using HDF5 as the storage layer, a user of the data product can take full advantage of tools and libraries readily available to access the data.

Every netCDF4 file is considered an HDF5 file, however, not every HDF5 file is necessarily a netCDF4 file. A limited subset of the HDF5 data model and file format features are used in netCDF4 files. Conformance to the earlier mentioned CF & ACDD standards allows for users to take advantage of most netCDF interfaces.

Tools and libraries for reading netCDF4 as well as a netCDF Users' Guide are written and maintained by Unidata and can be found online at:
http://www.unidata.ucar.edu/software/netcdf/

Panoply is a good netCDF data viewer tool for visualizing these files.
https://www.giss.nasa.gov/tools/panoply/

There are a number of interfaces available for reading netCDF for different programming languages including: C/C++, Fortran, Matlab, IDL, Python and Perl.

The files can also be accessed with HDF5 tools and libraries available at:
https://www.hdfgroup.org/products/hdf5_tools/

5.0 Data Services

The products are available to the user community via the GES DISC:
https://disc.gsfc.nasa.gov/

In addition to the netCDF data files, there you can also get daily granule maps, showing the location of each granule of each day.

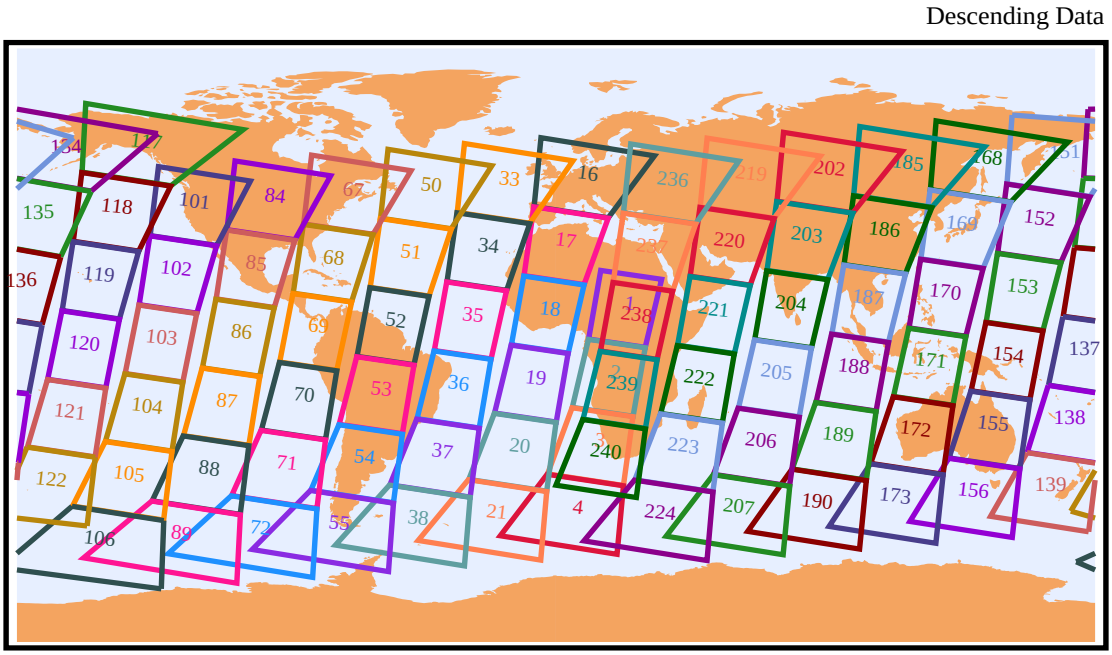


Figure 4. SNPP Granule map for nighttime data 2016-01-14.

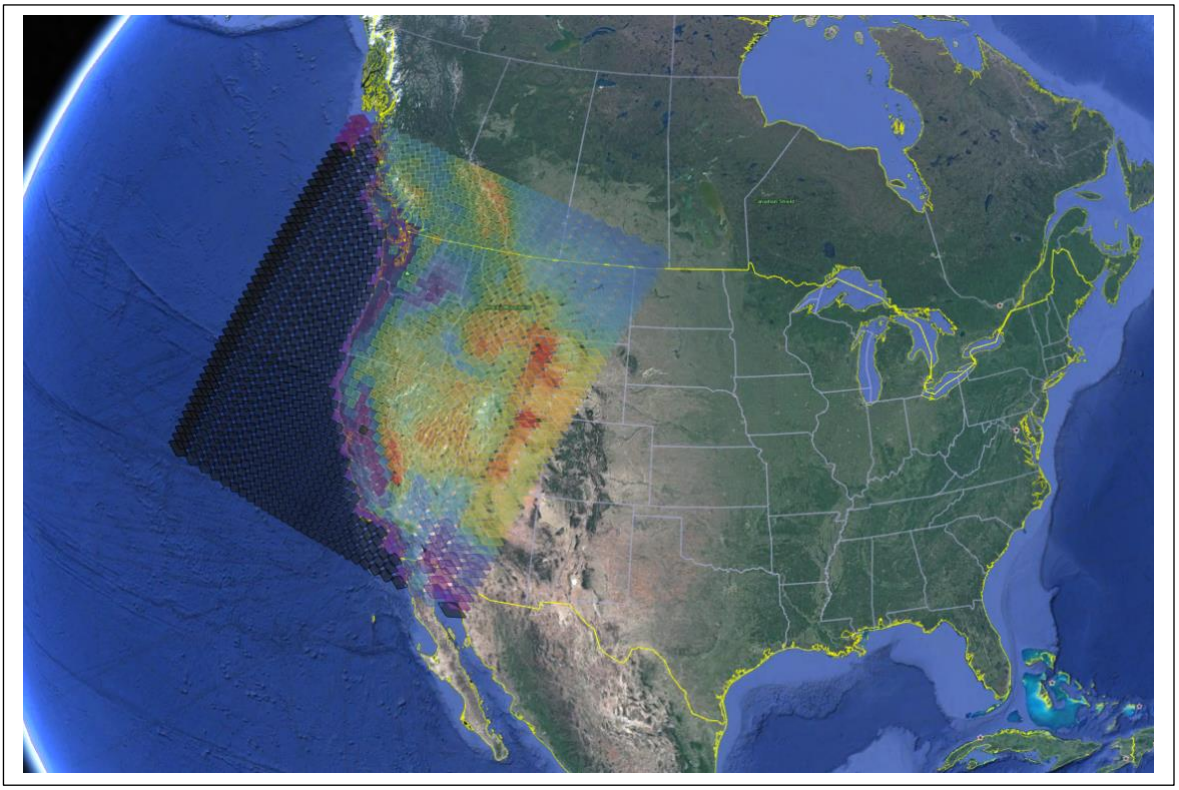
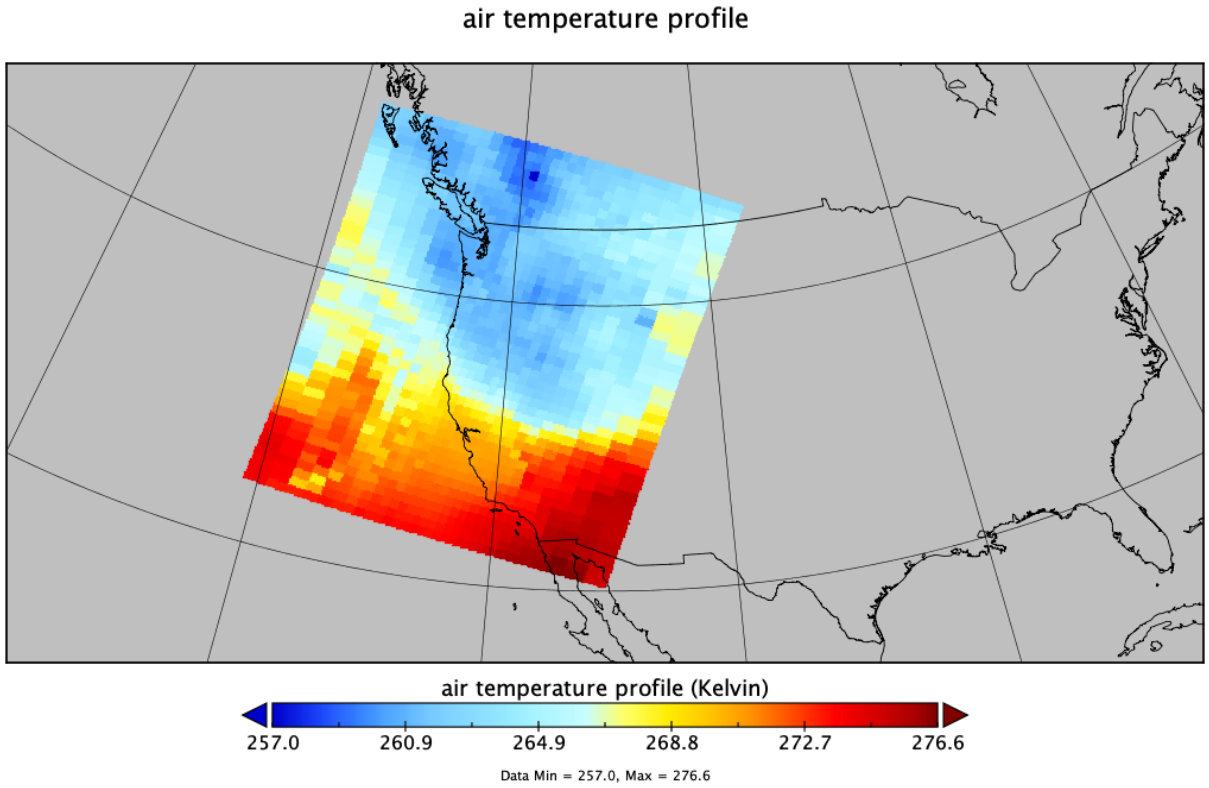


Figure 5. Bounding polygon for SNPP granule 101 from Figure 4 showing each FOR. This image colors FORs according to elevation and was created using Google Earth. This granule is also used in Appendix B: Sample Images.

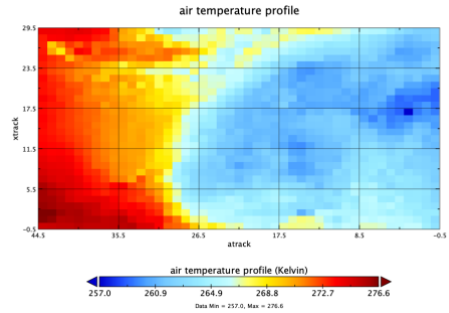
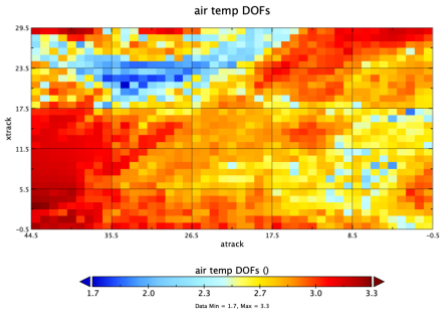
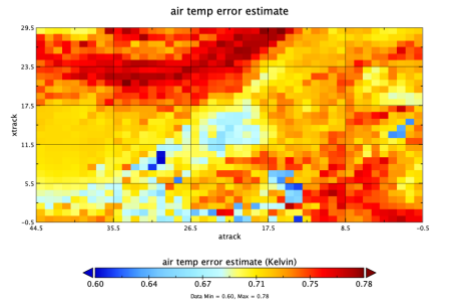
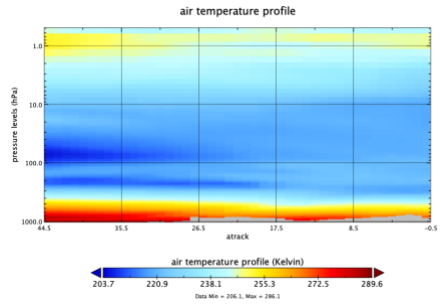
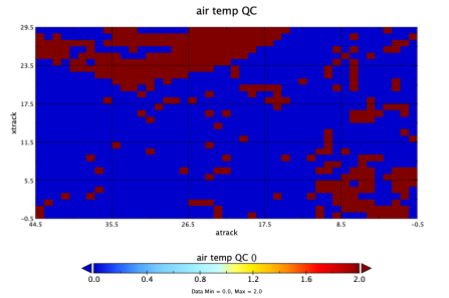
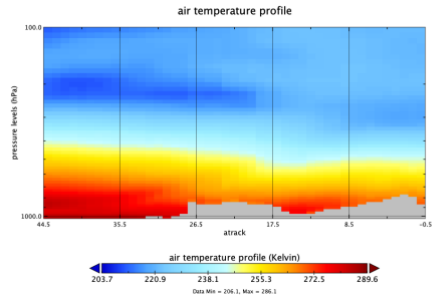
Appendix A: Sample images

These images for 2016-01-14 SNPP granule 101 (gran_id = 20160114T1005) were generated with Panoply. See section 4.0 for the link to obtaining and installing Panoply.

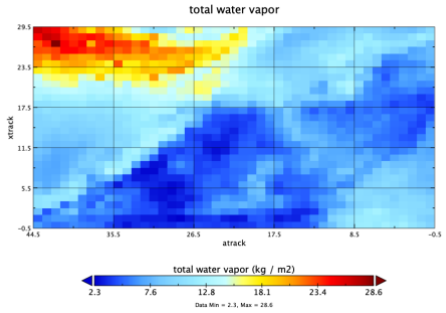
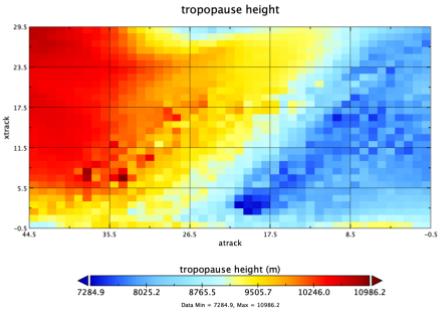
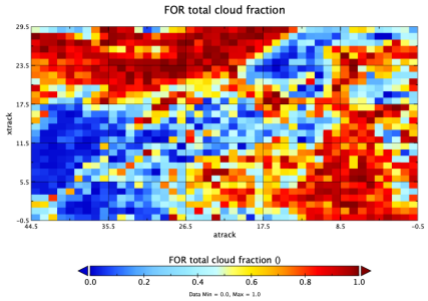
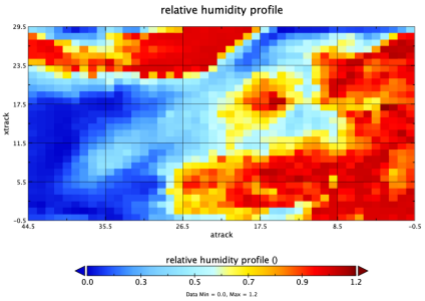
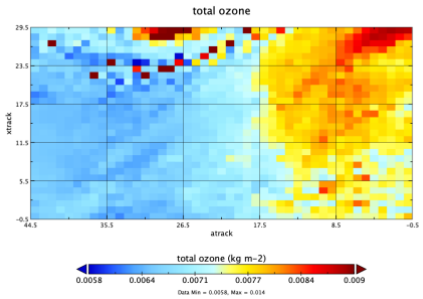
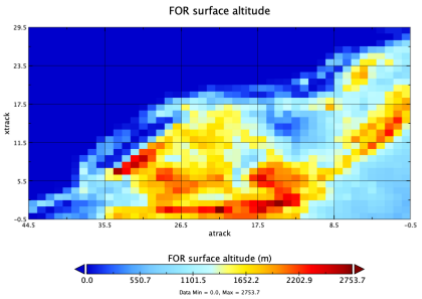
We show CLIMCAPS SNPP air_temp for level 85, which is 706564 Pa (= 707 hPa). This granule covers the western part of the US and the adjacent part of the Pacific Ocean at night.



Next we look at this level of air_temp in a simple rectangular grid of atrack x xtrack and as a vertical slice along the long axis. The Pacific Ocean is now at the top of each horizontal image and the Rocky Mountains near the bottom.

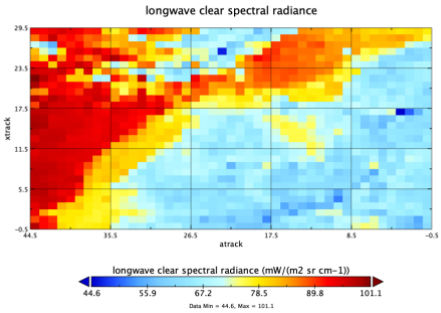
CLIMCAPS SNPP Air temperature images	
 **air_temp 707 hPa**	 **air_temp_dof**
 **air_temp_err 707 hPa**	 **air_temp vertical slice**
 **air_temp_qc 707 hPa**	 **air_temp troposphere vertical slice**

Here are some other granule images from the RET file.

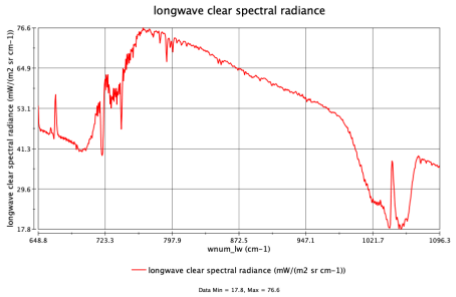
Other SNPP CLIMCAPS RET images	
 **Total water vapor**	 **Tropopause height**
 **Total cloud fraction**	 **Relative humidity**
 **Total ozone**	 **Surface altitude**

Looking at the SNPP cloud-cleared radiance product, LW channel 401, 898.75 cm^{-1}.

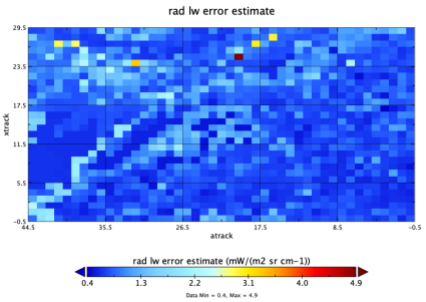
Cloud-Cleared Radiance images



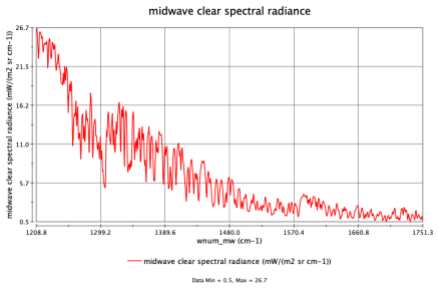
Radiance



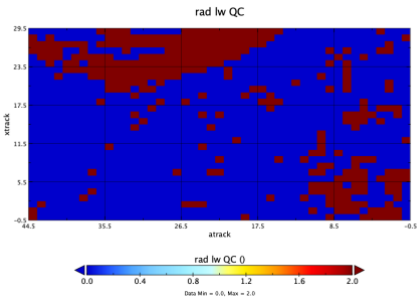
Longwave spectrum



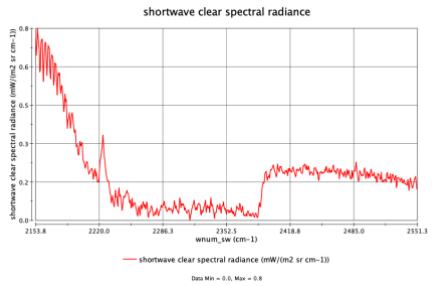
Radiance error estimate



Midwave spectrum



Radiance QC



Shortwave spectrum

Appendix B: Detailed file formats

The tables in this appendix list all the dimensions, global attributes, and variables in product files for both SNPP and JPSS-1. For SNPP, both NSR & FSR are supported by the tables below. Two level 2 product types defined below are: 1. retrieval and 2. cloud cleared radiances.

For clarity, some variable attributes are omitted, including long_name, standard_name, coverage_content_type, axis, valid_range, coordinates, AIRS_HDF_name, and _FillValue.

Ancillary variables are also omitted. The presence of “bnds” in the ancillary_variables column for “lat” means that there is also a variable named “lat_bnds”.

To get a complete listing including all variable attributes and the actual values contained in the header, apply “ncdump -h <filename>” to any netCDF4 product file.

B.1 CLIMCAPS Retrieval product

This section lists the interface specification for Level 2 CLIMCAPS retrieval product for SNPP. All the variables and attributes are similar for all platforms, except that the mw group is not present for Aqua IR-Only. The interface specification version is 02.02.05.

Table B.1.1 Global Groups

Path	Description
/	Main science data
/mw	MW-Only data
/mol_lay	Layer molecule amounts
/ave_kern	Averaging Kernels
/aux	Internal product team data

Table B.1.2 Global Dimensions

Name	Size	Description
fov	9	Field-of-view dimension
atrack	45	along-track horizontal dimension
xtrack	30	cross-track horizontal dimension
air_pres	100	Fine atmospheric pressure levels starting from the top
air_pres_h2o	66	Fine atmospheric pressure levels starting from the top
air_pres_lay	100	Fine atmospheric pressure layers starting from the top
surf_wnum_ir	100	IR surface emissivity hinge points
surf_freq_mw	13	MW surface emissivity hinge points
cld_lay	2	Measured cloud layers: top, bottom
bnds_1d	2	Boundaries for 1-d fields like air_pres_lay: min, max
fov_poly	8	lat_bnds, lon_bnds points defining the polygon bounding an FOV (anticlockwise as viewed from above)
utc_tuple	8	parts of UTC time: year, month, day, hour, minute, second, millisec, microsec
spatial	3	directions: x, y, z for satellite position and velocity

attitude	3	roll, pitch, yaw

Table B.1.3 Global Attributes

Name	Type	Size	Value	Description
keywords	string	1	ATMOSPHERE > ATMOSPHERIC TEMPERATURE > UPPER AIR TEMPERATURE\, ATMOSPHERE > ATMOSPHERIC WATER VAPOR > WATER VAPOR	A comma-separated list of key words and/or phrases. Keywords may be common words or phrases, terms from a controlled vocabulary (GCMD is often used), or URIs for terms from a controlled vocabulary (see also "keywords_vocabulary" attribute).
Conventions	string	1	CF-1.6\, ACDD-1.3	A comma-separated list of the conventions that are followed by the dataset.
history	string	1		Provides an audit trail for modifications to the original data. This attribute is also in the NetCDF Users Guide: 'This is a character array with a line for each invocation of a program that has modified the dataset. Well-behaved generic netCDF applications should append a line containing: date, time of day, user name, program name and command arguments.' To include a more complete description you can append a reference to an ISO Lineage entity; see NOAA EDM ISO Lineage guidance.
source	string	1	CrIS and ATMS instrument telemetry	The method of production of the original data. If it was model-generated, source should name the model and its version. If it is observational, source should characterize it. This attribute is defined in the CF Conventions. Examples: 'temperature from CTD #1234'; 'world model v.0.1'.
processing_level	string	1	2	A textual description of the processing (or quality control) level of the data.
product_name_type_id	string	1	L2_CLIMCAPS_RET_NSR	Product name as it appears in product_name (L1A, L1B, L2, SNO_AIRS_CrIS)
comment	string	1		Miscellaneous information about the data or methods used to produce it. Can be empty.

acknowledgment	string	1	Support for this research was provided by NASA.	A place to acknowledge various types of support for the project that produced this data.
license	string	1	Limited to Sounder SIPS affiliates	Provide the URL to a standard or specific license, enter "Freely Distributed" or "None", or describe any restrictions to data access and distribution in free text.
standard_name_vocabulary	string	1	CF Standard Name Table v28	The name and version of the controlled vocabulary from which variable standard names are taken. (Values for any standard_name attribute must come from the CF Standard Names vocabulary for the data file or product to comply with CF.) Example: 'CF Standard Name Table v27'.
date_created	string	1	Unassigned	The date on which this version of the data was created. (Modification of values implies a new version, hence this would be assigned the date of the most recent values modification.) Metadata changes are not considered when assigning the date_created. The ISO 8601:2004 extended date format is recommended, as described in the Attribute Content Guidance section.
creator_name	string	1	Unassigned	The name of the person (or other creator type specified by the creator_type attribute) principally responsible for creating this data.
creator_email	string	1	Unassigned	The email address of the person (or other creator type specified by the creator_type attribute) principally responsible for creating this data.
creator_url	string	1	Unassigned	The URL of the person (or other creator type specified by the creator_type attribute) principally responsible for creating this data.
institution	string	1	Unassigned	Processing facility that produced this file
project	string	1	Sounder SIPS	The name of the project(s) principally responsible for originating this data. Multiple projects can be separated by commas, as described under Attribute Content Guidelines. Examples: 'PATMOS-X', 'Extended Continental Shelf Project'.
product_name_project	string	1	SNDR	The name of the project as it appears in the file name. 'SNDR' for all Sounder SIPS products, even AIRS products.
publisher_name	string	1	Unassigned	The name of the person (or other entity specified by the publisher_type attribute) responsible for publishing the data file or product to users, with its current metadata and format.

publisher_email	string	1	Unassigned	The email address of the person (or other entity specified by the publisher_type attribute) responsible for publishing the data file or product to users, with its current metadata and format.
publisher_url	string	1	Unassigned	The URL of the person (or other entity specified by the publisher_type attribute) responsible for publishing the data file or product to users, with its current metadata and format.
geospatial_bounds	string	1		Describes the data's 2D or 3D geospatial extent in OGC's Well-Known Text (WKT) Geometry format (reference the OGC Simple Feature Access (SFA) specification). The meaning and order of values for each point's coordinates depends on the coordinate reference system (CRS). The ACDD default is 2D geometry in the EPSG:4326 coordinate reference system. The default may be overridden with geospatial_bounds_crs and geospatial_bounds_vertical_crs (see those attributes). EPSG:4326 coordinate values are latitude (decimal degrees_north) and longitude (decimal degrees_east), in that order. Longitude values in the default case are limited to the (-180, 180) range. Example: 'POLYGON ((40.26 -111.29, 41.26 -111.29, 41.26 -110.29, 40.26 -110.29, 40.26 -111.29))'.
geospatial_bounds_crs	string	1	EPSG:4326	The coordinate reference system (CRS) of the point coordinates in the geospatial_bounds attribute. This CRS may be 2-dimensional or 3-dimensional, but together with geospatial_bounds_vertical_crs, if that attribute is supplied, must match the dimensionality, order, and meaning of point coordinate values in the geospatial_bounds attribute. If geospatial_bounds_vertical_crs is also present then this attribute must only specify a 2D CRS. EPSG CRSs are strongly recommended. If this attribute is not specified, the CRS is assumed to be EPSG:4326. Examples: 'EPSG:4979' (the 3D WGS84 CRS), 'EPSG:4047'.
geospatial_lat_min	float	1	9.9692099683868690e+36f	Describes a simple lower latitude limit; may be part of a 2- or 3-dimensional bounding region. Geospatial_lat_min specifies the southernmost latitude covered by the dataset.
geospatial_lat_max	float	1	9.9692099683868690e+36f	Describes a simple upper latitude limit; may be part of a 2- or 3-dimensional bounding region. Geospatial_lat_max specifies the northernmost latitude covered by the dataset.

geospatial_lon_min	float	1	9.9692099683868690e+36f	Describes a simple longitude limit; may be part of a 2- or 3-dimensional bounding region. geospatial_lon_min specifies the westernmost longitude covered by the dataset. See also geospatial_lon_max.
geospatial_lon_max	float	1	9.9692099683868690e+36f	Describes a simple longitude limit; may be part of a 2- or 3-dimensional bounding region. geospatial_lon_max specifies the easternmost longitude covered by the dataset. Cases where geospatial_lon_min is greater than geospatial_lon_max indicate the bounding box extends from geospatial_lon_max, through the longitude range discontinuity meridian (either the antimeridian for -180:180 values, or Prime Meridian for 0:360 values), to geospatial_lon_min; for example, geospatial_lon_min=170 and geospatial_lon_max=-175 incorporates 15 degrees of longitude (ranges 170 to 180 and -180 to -175).
time_coverage_start	string	1		Nominal start time. Describes the time of the first data point in the data set. Use the ISO 8601:2004 date format, preferably the extended format as recommended in the Attribute Content Guidance section.
time_of_first_valid_obs	string	1		Describes the time of the first valid data point in the data set. Use the ISO 8601:2004 date extended format.
time_coverage_mid	string	1		Describes the midpoint between the nominal start and end times. Use the ISO 8601:2004 date format, preferably the extended format as recommended in the Attribute Content Guidance section.
time_coverage_end	string	1		Nominal end time. Describes the time of the last data point in the data set. Use ISO 8601:2004 date format, preferably the extended format as recommended in the Attribute Content Guidance section.
time_of_last_valid_obs	string	1		Describes the time of the last valid data point in the data set. Use the ISO 8601:2004 date extended format.
time_coverage_duration	string	1	P0000-00-00T00:06:00	Describes the duration of the data set. Use ISO 8601:2004 duration format, preferably the extended format as recommended in the Attribute Content Guidance section.
product_name_duration	string	1	m06	Product duration as it appears in product_name (m06 means six minutes)

creator_type	string	1	institution	Specifies type of creator with one of the following: 'person', 'group', 'institution', or 'position'. If this attribute is not specified, the creator is assumed to be a person.
creator_institution	string	1	Jet Propulsion Laboratory -- California Institute of Technology	The institution of the creator; should uniquely identify the creator's institution. This attribute's value should be specified even if it matches the value of publisher_institution, or if creator_type is institution.
product_version	string	1	v02.28.02	Version identifier of the data file or product as assigned by the data creator. For example, a new algorithm or methodology could result in a new product_version.
keywords_vocabulary	string	1	GCMD:GCMD Keywords	If you are using a controlled vocabulary for the words/phrases in your "keywords" attribute, this is the unique name or identifier of the vocabulary from which keywords are taken. If more than one keyword vocabulary is used, each may be presented with a prefix and a following comma, so that keywords may optionally be prefixed with the controlled vocabulary key. Example: 'GCMD:GCMD Keywords, CF:NetCDF COARDS Climate and Forecast Standard Names'.
platform	string	1	SUOMI-NPP > Suomi National Polar-orbiting Partnership	Name of the platform(s) that supported the sensor data used to create this data set or product. Platforms can be of any type, including satellite, ship, station, aircraft or other. Indicate controlled vocabulary used in platform_vocabulary.
platform_vocabulary	string	1	GCMD:GCMD Keywords	Controlled vocabulary for the names used in the "platform" attribute.
product_name_platform	string	1	SNPP	Platform name as it appears in product_name
instrument	string	1	CRIMSS > Cross-track Infrared and Advanced Technology Microwave Sounders\, CrIS > Cross-track Infrared Sounder\, ATMS > Advanced Technology Microwave Sounder	Name of the contributing instrument(s) or sensor(s) used to create this data set or product. Indicate controlled vocabulary used in instrument_vocabulary.
instrument_vocabulary	string	1	GCMD:GCMD Keywords	Controlled vocabulary for the names used in the "instrument" attribute.
product_name_instr	string	1	CRIMSS	Instrument name as it appears in product_name
product_name	string	1		Canonical fully qualified product name (official file name)

product_name_variant	string	1	std	Processing variant identifier as it appears in product_name. 'std' (shorthand for 'standard') is to be the default and should be what is seen in all public products.
product_name_version	string	1	vxx_xx_xx	Version number as it appears in product_name (v01_00_00)
product_name_producer	string	1	T	Production facility as it appears in product_name (single character) 'T' is the default, for unofficial local test products
product_name_timestamp	string	1	yymmddhhmmss	Processing timestamp as it appears in product_name (yymmddhhmmss)
product_name_extension	string	1	nc	File extension as it appears in product_name (typically nc)
granule_number	ushort	1		granule number of day (1-240)
product_name_granule_number	string	1	g000	zero-padded string for granule number of day (g001-g240)
gran_id	string	1	yyyymmddThhmm	Unique granule identifier yyyymmddThhmm of granule start, including year, month, day, hour, and minute of granule start time
geospatial_lat_mid	float	1	9.9692099683868690e+36f	granule center latitude
geospatial_lon_mid	float	1	9.9692099683868690e+36f	granule center longitude
featureType	string	1	point	structure of data in file
data_structure	string	1	swath	a character string indicating the internal organization of the data with currently allowed values of 'grid', 'station', 'trajectory', or 'swath'. The 'structure' here generally describes the horizontal structure and in all cases data may also be functions, for example, of a vertical coordinate and/or time. (If using CMOR pass this in a call to cmor_set_cur_dataset_attribute.)
cdm_data_type	string	1	Swath	The data type, as derived from Unidata's Common Data Model Scientific Data types and understood by THREDDS. (This is a THREDDS "dataType", and is different from the CF NetCDF attribute 'featureType', which indicates a Discrete Sampling Geometry file in CF.)

id	string	1	Unassigned	An identifier for the data set, provided by and unique within its naming authority. The combination of the "naming authority" and the "id" should be globally unique, but the id can be globally unique by itself also. IDs can be URLs, URNs, DOIs, meaningful text strings, a local key, or any other unique string of characters. The id should not include white space characters.
naming_authority	string	1	Unassigned	The organization that provides the initial id (see above) for the dataset. The naming authority should be uniquely specified by this attribute. We recommend using reverse-DNS naming for the naming authority; URIs are also acceptable. Example: 'edu.ucar.unidata'.
identifier_product_doi	string	1	Unassigned	digital signature
identifier_product_doi_authority	string	1	Unassigned	digital signature source
algorithm_version	string	1		The version of the algorithm in whatever format is selected by the developers. After the main algorithm name and version, versions from multiple sub-algorithms may be concatenated with semicolon separators. (ex: 'CCAST 4.2; BB emis from MIT 2016-04-01') Must be updated with every delivery that changes numerical results.
production_host	string	1		Identifying information about the host computer for this run. (Output of linux "uname -a" command.)
format_version	string	1	v02.01.06	Format version.
input_file_names	string	1		Semicolon-separated list of names or unique identifiers of files that were used to make this product. There will always be one space after each semicolon. There is no final semicolon.
input_file_types	string	1		Semicolon-separated list of tags giving the role of each input file in input_file_names. There will always be one space after each semicolon. There is no final semicolon.
input_file_dates	string	1		Semicolon-separated list of creation dates for each input file in input_file_names. There will always be one space after each semicolon. There is no final semicolon.
orbitDirection	string	1		Orbit is ascending and/or descending. Values are "Ascending" or "Descending" if the entire granule fits that description. "NorthPole" and "SouthPole" are used for polar-crossing granules. "NA" is used when a determination cannot be made.

day_night_flag	string	1		Data is day or night. "Day" means subsatellite point for all valid scans has solar zenith angle less than 90 degrees. "Night" means subsatellite point for all valid scans has solar zenith angle greater than 90 degrees. "Both" means the dataset contains valid observations with solar zenith angle above and below 90 degrees. "NA" means a value could not be determined.
AutomaticQualityFlag	string	1	Missing	"Passed": the granule contains a non-degraded calibrated brightness temperature, radiance, or retrieved value for at least one value in a geolocated FOV; "Suspect": the granule does not qualify as "Passed" but contains a (possibly degraded) calibrated or retrieved value (possibly without associated geolocation); "Failed": the granule contains no calibrated or retrieved values.
qa_pct_data_missing	float	1		Percentage of expected observations that are missing.
qa_pct_data_geo	float	1		Percentage of expected observations that are successfully geolocated.
qa_pct_data_sci_mode	float	1		Percentage of expected observations that were taken while the instrument was in science mode and are successfully geolocated.
qa_no_data	string	1	TRUE	A simple indicator of whether this is an "empty" granule with no data from the instrument. "TRUE" or "FALSE".
title	string	1	Level-2 CLIMCAPS SNPP CrIMSS	a succinct description of what is in the dataset. (= ECS long name)
summary	string	1	The Level-2 CLIMCAPS product includes atmospheric state retrieval products from the CLIMCAPS algorithm for one six-minute interval. These include temperature and water vapor profiles as well as cloud and surface products and minor gases.	A paragraph describing the dataset, analogous to an abstract for a paper.
shortname	string	1	SNDRSNIML2CCPRET	ECS Short Name
product_group	string	1	l2_crimss	The group name to be used for this product when it is collected in a multi-group file type, like SNO or calsub
metadata_link	string	1	Unassigned	A URL that gives the location of more complete metadata. A persistent URL is recommended for this attribute.

references	string	1		ATDB and design documents describing processing algorithms. Can be empty.
contributor_name	string	1	Christopher D. Barnet\, STC; L. Larrabee Strow\, UMBC; Philip W. Rosenkranz\, MIT	The names of any individuals or institutions that contributed to the creation of this data.
contributor_role	string	1	Retrieval PI; Forward Model PI; Microwave PI	The roles of any individuals or institutions that contributed to the creation of this data.

Table B.1.4 Global Variables

Name	Type	Dimensions	Description	Units	Ancillary Variables
obs_id	string	atrack, xtrack	unique earth view observation identifier: yyyymmddThhmm.aaExx. Includes gran_id plus 2-digit along-track index (01-45) and 2-digit cross-track index (01-30).		
fov_obs_id	string	atrack, xtrack, fov	unique earth view observation identifier for FOV: yyyymmddThhmm.aaExx.f . Includes gran_id plus 2-digit along-track index (01-45), 2-digit cross-track index (01-30), and 1-digit FOV number (1-9).		
obs_time_tai93	double	atrack, xtrack	earth view observation midtime for each FOV	seconds since 1993-01-01 00:00	bnds
obs_time_utc	uint16	atrack, xtrack, utc_tuple	UTC earth view observation time as an array of integers: year, month, day, hour, minute, second, millisec, microsec		
lat	float	atrack, xtrack	latitude of FOR center	degrees_north	bnds
lat_geoid	float	atrack, xtrack	latitude of FOR center on the geoid (without terrain correction)	degrees_north	
fov_lat	float	atrack, xtrack, fov	latitude of FOV center	degrees_north	bnds
lon	float	atrack, xtrack	longitude of FOR center	degrees_east	bnds
lon_geoid	float	atrack, xtrack	longitude of FOR center on the geoid (without terrain correction)	degrees_east	
fov_lon	float	atrack, xtrack, fov	longitude of FOV center	degrees_east	bnds
land_frac	float	atrack, xtrack	land fraction over the FOR	unitless	
fov_land_frac	float	atrack, xtrack, fov	land fraction over the FOV	unitless	
surf_alt	float	atrack, xtrack	mean surface altitude wrt earth model over the FOR	m	

fov_surf_alt	float	atrack, xtrack, fov	mean surface altitude wrt earth model over the FOV	m	
surf_alt_sdev	float	atrack, xtrack	standard deviation of surface altitude within the FOR	m	
fov_surf_alt_sdev	float	atrack, xtrack, fov	standard deviation of surface altitude within the FOV	m	
sun_glint_lat	float	atrack	sun glint spot latitude at scan_mid_time. Fill for night observations.	degrees_north	
sun_glint_lon	float	atrack	sun glint spot longitude at scan_mid_time. Fill for night observations.	degrees_east	
sol_zen	float	atrack, xtrack	solar zenith angle at the center of the spot	degree	
sol_azi	float	atrack, xtrack	solar azimuth angle at the center of the spot (clockwise from North)	degree	
sun_glint_dist	float	atrack, xtrack	distance of sun glint spot to the center of the spot. Fill for night observations.	m	
view_ang	float	atrack, xtrack	off nadir pointing angle	degree	
sat_zen	float	atrack, xtrack	satellite zenith angle at the center of the spot	degree	
sat_azi	float	atrack, xtrack	satellite azimuth angle at the center of the spot (clockwise from North)	degree	
sat_range	float	atrack, xtrack	line of sight distance between satellite and spot center	m	
asc_flag	ubyte	atrack	ascending orbit flag: 1 if ascending, 0 descending		
subsat_lat	float	atrack	sub-satellite latitude at scan_mid_time	degrees_north	
subsat_lon	float	atrack	sub-satellite longitude at scan_mid_time	degrees_east	
scan_mid_time	double	atrack	TAI93 at middle of earth scene scans	seconds since 1993-01-01 00:00	
sat_alt	float	atrack	satellite altitude with respect to earth model at scan_mid_time	m	
sat_pos	float	atrack, spatial	satellite ECR position at scan_mid_time	m	
sat_vel	float	atrack, spatial	satellite ECR velocity at scan_mid_time	m s-1	
sat_att	float	atrack, attitude	satellite attitude at scan_mid_time. An orthogonal triad. First element is angle about the +x (roll) ORB axis. +x axis is positively oriented in the direction of orbital flight. Second element is angle about +y (pitch) ORB axis. +y axis is oriented normal to the orbit plane with the positive sense opposite to that of the orbit's angular momentum vector H. Third element is angle about +z (yaw) axis. +z axis is positively oriented Earthward parallel to the satellite radius vector R from the spacecraft center of mass to the center of the Earth.	degree	
local_solar_time	float	atrack, xtrack	local apparent solar time in hours from midnight	hours	

mean_anom_wrt_equat	float	atrack	spacecraft mean anomaly measured with respect to the ascending node	degree	
sat_sol_zen	float	atrack	solar zenith angle at the satellite	degree	
sat_sol_azi	float	atrack	solar azimuth angle at the satellite (clockwise from North)	degree	
asc_node_lon	float		Longitude of the last ascending node of spacecraft orbit before time_coverage_end.	degrees_east	
asc_node_tai93	double		TAI93 time of the last ascending node of spacecraft orbit before time_coverage_end.	seconds since 1993-01-01 00:00	
asc_node_local_solar_time	float		local apparent solar time at the last ascending node before time_coverage_end in hours from midnight	hours	
solar_beta_angle	float		Beta angle for the spacecraft orbit, determining the percentage of the orbit that the spacecraft is in direct sunlight.	degree	
attitude_lbl	string	attitude	list of rotational directions (roll, pitch, yaw)		
spatial_lbl	string	spatial	list of spatial directions (X, Y, Z)		
utc_tuple_lbl	string	utc_tuple	names of the elements of UTC when it is expressed as an array of integers year,month,day,hour,minute,second,millisecond,microsecond		
air_temp	float32	atrack, xtrack, air_pres	air temperature profile	Kelvin	err, qc
surf_air_temp	float32	atrack, xtrack	near-surface air temperature (~2 meters above surface)	Kelvin	err, qc
air_temp_dof	float32	atrack, xtrack	The trace of the averaging kernel matrix as a measure of the number of pieces of information about the air temperature profile provided by the physical retrieval step.	unitless	
h2o_vap_tot	float32	atrack, xtrack	total precipitable water vapor	kg / m2	err, qc
spec_hum	float32	atrack, xtrack, air_pres_h2o	mass fraction of water vapor in moist air	kg / kg	err, qc
surf_spec_hum	float32	atrack, xtrack	Near-surface mass fraction of water vapor in moist air	kg / kg	err, qc
h2o_vap_dof	float32	atrack, xtrack	The trace of the averaging kernel matrix as a measure of the number of pieces of information about the water vapor profile provided by the physical retrieval step.	unitless	
rel_hum	float32	atrack, xtrack, air_pres_h2o	relative humidity over equilibrium phase	unitless	err, qc
surf_rel_hum	float32	atrack, xtrack	relative humidity near the surface over equilibrium phase	unitless	err, qc
spec_hum_sat_ice	float32	atrack, xtrack, air_pres_h2o	saturation specific humidity in equilibrium with ice	kg / kg	err, qc

surf_spec_hum_sat_ice	float32	atrack, xtrack	Near-surface saturation specific humidity in equilibrium with ice	kg / kg	err, qc
spec_hum_sat_liq	float32	atrack, xtrack, air_pres_h2o	saturation specific humidity in equilibrium with liquid water	kg / kg	err, qc
surf_spec_hum_sat_liq	float32	atrack, xtrack	Near-surface saturation specific humidity in equilibrium with liquid water	kg / kg	err, qc
gp_hgt	float32	atrack, xtrack, air_pres	Geopotential is the sum of the specific gravitational potential energy relative to the geoid and the specific centripetal potential energy. Geopotential height is the geopotential divided by the standard acceleration due to gravity.	m	err, qc
surf_gp_hgt	float32	atrack, xtrack	geopotential height at the surface	m	err, qc
o3_tot	float32	atrack, xtrack	Total column ozone. (Multiply by 4.670e5 to convert to Dobson Units from kg m^-2)	kg m-2	err, qc
o3_mmr	float32	atrack, xtrack, air_pres	ozone mass mixing ratio to dry air	kg / kg	err, qc
o3_dof	float32	atrack, xtrack	The trace of the averaging kernel matrix as a measure of the number of pieces of information about the ozone profile provided by the physical retrieval step.	unitless	
co_mmr_midtrop	float32	atrack, xtrack	Carbon monoxide mass mixing ratio to dry air at 50000 Pa, near the peak of sensitivity	kg / kg	err, qc
co_dof	float32	atrack, xtrack	The trace of the averaging kernel matrix as a measure of the number of pieces of information about the carbon monoxide profile provided by the physical retrieval step.	unitless	
ch4_mmr_midtrop	float32	atrack, xtrack	Methane mass mixing ratio to dry air at 40000 Pa, near the peak of sensitivity	kg / kg	err, qc
ch4_dof	float32	atrack, xtrack	The trace of the averaging kernel matrix as a measure of the number of pieces of information about the methane profile provided by the physical retrieval step.	unitless	
co2_dof	float32	atrack, xtrack	The trace of the averaging kernel matrix as a measure of the number of pieces of information about the carbon dioxide profile provided by the physical retrieval step.	unitless	
n2o_dof	float32	atrack, xtrack	The trace of the averaging kernel matrix as a measure of the number of pieces of information about the nitrous oxide profile provided by the physical retrieval step.	unitless	
hno3_dof	float32	atrack, xtrack	The trace of the averaging kernel matrix as a measure of the number of pieces of information about the nitric acid profile provided by the physical retrieval step.	unitless	

so2_dof	float32	atrack, xtrack	The trace of the averaging kernel matrix as a measure of the number of pieces of information about the sulfur dioxide profile provided by the physical retrieval step.	unitless	
mw_cld_phase	int16	atrack, xtrack, air_pres_lay	Cloud Ice/Water flag from microwave. 0 for liquid clouds or no clouds; 1 for ice clouds.		
h2o_liq_tot	float32	atrack, xtrack	total column cloud liquid water	kg m-2	err, qc
h2o_liq_mol_lay	float32	atrack, xtrack, air_pres_lay	cloud liquid water layer total	unitless	err, qc
surf_temp	float32	atrack, xtrack	radiative temperature of the surface	Kelvin	err, qc
surf_temp_dof	float32	atrack, xtrack	The trace of the averaging kernel matrix as a measure of the number of pieces of information about the surface provided by the physical retrieval step.	unitless	
surf_ir_emis	float32	atrack, xtrack, surf_wnum_ir	infrared surface emissivity	unitless	err, qc
surf_ir_refl	float32	atrack, xtrack, surf_wnum_ir	infrared surface reflectivity	unitless	qc
surf_ir_wnum_cnt	int16	atrack, xtrack	Number of infrared surface emissivity frequencies	unitless	
surf_ir_wnum	float32	atrack, xtrack, surf_wnum_ir	Surface infrared emissivity frequencies (hinge points)	cm-1	
surf_mw_emis	float32	atrack, xtrack, surf_freq_mw	Microwave surface emissivity	unitless	err, qc
cld_frac	float32	atrack, xtrack, fov, cld_lay	effective cloud fraction	unitless	err, qc
cld_top_pres	float32	atrack, xtrack, fov, cld_lay	cloud top pressure in order of increasing pressure	Pa	err, qc
cld_top_temp	float32	atrack, xtrack, fov, cld_lay	cloud top temperature	Kelvin	err, qc
num_cld	byte	atrack, xtrack, fov	Number of cloud layers with nonzero cloud fraction	unitless	qc
tpause_gp_hgt	float32	atrack, xtrack	tropopause geopotential height, where tropopause is determined according to the WMO definition	m	qc
tpause_pres	float32	atrack, xtrack	tropopause pressure, where tropopause is determined according to the WMO definition	Pa	qc
tpause_temp	float32	atrack, xtrack	tropopause temperature, where tropopause is determined according to the WMO definition	Kelvin	qc

ir_precip_est_24 hr	float32	atrack, xtrack, fov	The thickness of a layer of liquid water equivalent to the estimated preciptitation over 24 hours.	m	err, qc
air_pres_nsurf	int16	atrack, xtrack	Index in air_pres of the level at the surface. Values at levels beyond this are invalid, representing data below the Earth's surface.	unitless	
air_pres_h2o_nsu rf	int16	atrack, xtrack	Index in air_pres_h2o of the level at the surface. Values at levels beyond this are invalid, representing data below the Earth's surface.	unitless	
air_pres_lay_nsur f	int16	atrack, xtrack	Index in air_pres_lay of the layer at the surface. Values for layers beyond this are invalid, representing data below the Earth's surface.	unitless	
air_pres	float32	air_pres	pressure levels	Pa	
air_pres_h2o	float32	air_pres_h2o	H2O vapor pressure levels	Pa	
air_pres_lay	float32	air_pres_lay	pressure at the middle of each layer	Pa	bnds
cld_lay_lbl	string	cld_lay	Cloud layer {top, bottom}		
mw_surf_class	int16	atrack, xtrack	Microwave spectral surface class. 0 for coastline; 1 for land; 2 for ocean; 3 for first-year sea-ice; 4 for multi-year sea-ice; 5 for snow (higher-freq scattering); 6 for glacier/snow (very low-freq scattering); 7 for snow (lower-freq scattering);		
surf_freq_mw	float32	surf_freq_mw	Microwave surface emissivity frequencies (hinge points)	Hz	

Table B.1.5 aux Variables

Name	Type	Dimensions	Description	Units	Ancillary Variables
co2_vmr	float32	atrack, xtrack, air_pres	carbon dioxide volume mixing ratio	m3 / m3	err, qc
for_cld_frac_tot	float32	atrack, xtrack	Field-Of-Regard effective cloud fraction summed over all cloud layers	unitless	err, qc
for_cld_top_pres_tot	float32	atrack, xtrack	Field-Of-Regard weighted cloud top pressure	Pa	err, qc
for_cld_frac_2lay	float32	atrack, xtrack, cld_lay	Effective cloud fraction assuming 2 common cloud layers over the whole Field-Of-Regard	unitless	err, qc
for_cld_top_pres_2lay	float32	atrack, xtrack, cld_lay	Cloud top pressure assuming 2 common cloud layers over the whole Field-of-Regard	Pa	err, qc
surf_dew_point_temp	float32	atrack, xtrack	Near-surface dew-point temperature	Kelvin	qc
surf_h2o_vap_pres_deficit	float32	atrack, xtrack	Near-surface water vapor saturation pressure deficit	Pa	qc

clim_surf_ir_emis	float32	atrack, xtrack, surf_wnum_ir	Infrared surface emissivity from the climatology first guess	unitless	
clim_surf_ir_refl	float32	atrack, xtrack, surf_wnum_ir	infrared surface reflectivity from the climatology first guess	unitless	
clim_surf_ir_wnum_cnt	int16	atrack, xtrack	Number of infrared surface emissivity frequencies for the climatology first guess	unitless	
clim_surf_ir_wnum	float32	atrack, xtrack, surf_wnum_ir	Surface infrared emissivity frequencies (hinge points) for the climatology first guess	cm-1	
clim_co2_mmr	float32	atrack, xtrack	Assumed carbon dioxide concentration	kg / kg	
prior_surf_pres	float32	atrack, xtrack	surface pressure from forecast	Pa	
prior_sea_lev_pres	float32	atrack, xtrack	sea level surface pressure from forecast	Pa	
idprof	string	atrack, xtrack	profile ID		
etarej	float32	atrack, xtrack	cloud clearing residual used f/ rej at iteration = ieta_rej	unitless	
cldfrc_tot	float32	atrack, xtrack	Total cloud fraction over FOR	unitless	
cldfrc_500	float32	atrack, xtrack	Total cloud fraction over FOR below 500 hPa	unitless	
ampl_eta	float32	atrack, xtrack	cloud clearing noise amplification factor	unitless	
ir_x	float32	atrack, xtrack	RMS(rad(IR.ret)-radobs()) for AMSU channels	unitless	
bt2	float32	atrack, xtrack	RMS(T(p) f/IR.ret - T(p) f/ AMSU.ret)	unitless	
qualsurf	float32	atrack, xtrack	qualsurf		
qualtemp	float32	atrack, xtrack	qualtemp		
softcode	float32	atrack, xtrack	software rejection code		
aeff_1	float32	atrack, xtrack	A_eff(1st eta step)	unitless	
aeff_end	float32	atrack, xtrack	A_eff(last eta step)	unitless	
a0_cloud	float32	atrack, xtrack	intercept of alpha(1)=f(alpha(2)) fitting	unitless	
totliqwat	float32	atrack, xtrack	total liquid water (MW)	unitless	
c5h8_dbt	float32	atrack, xtrack, fov	Brightness temperature difference near 893 cm-1 indicating isoprene. Values over +0.05 K are potential detections. Experimental.	Kelvin	
c2h6_dbt	float32	atrack, xtrack, fov	Brightness temperature difference near 823 cm-1 indicating ethane. Values over +0.05 K are potential detections. Experimental.	Kelvin	
c3h6_dbt	float32	atrack, xtrack, fov	Brightness temperature difference near 911 cm-1 indicating propylene. Values over +0.05 K are potential detections. Experimental.	Kelvin	

nh3_dbt	float32	atrack, xtrack, fov	Brightness temperature difference sum indicating ammonia. Sum of lines near 929 and 966 cm-1. Values over +1.0 K are potential detections. Experimental.	Kelvin	
blue_spike_fire	float32	atrack, xtrack, fov	Blue spike fire signal strength. Experimental.	unitless	
fg_air_temp	float32	atrack, xtrack, air_pres	air temperature profile from the MERRA2 first guess	Kelvin	
fg_h2o_vap_mol_lay	float32	atrack, xtrack, air_pres_lay	water vapor layer totals from the MERRA2 first guess	molecules / m2	
fg_o3_mol_lay	float32	atrack, xtrack, air_pres_lay	Ozone layer total from the MERRA2 first guess	molecules / m2	
fg_surf_air_temp	float32	atrack, xtrack	near-surface air temperature (~2 meters above surface) from the MERRA2 first guess	Kelvin	
fg_surf_temp	float32	atrack, xtrack	radiative temperature of the surface from the MERRA2 first guess	Kelvin	
fov_weight	float32	atrack, xtrack, fov	Contribution weighting of FOV within FOR for cloud cleared radiances. Can be negative.	unitless	
chi2_temp	float32	atrack, xtrack	Temperature profile chi^2 of alpha(1)=f(alpha(2)) fitting	unitless	
chi2_h2o	float32	atrack, xtrack	Water vapor chi^2 of alpha(1)=f(alpha(2)) fitting	unitless	
chi2_o3	float32	atrack, xtrack	Ozone chi^2 of alpha(1)=f(alpha(2)) fitting	unitless	
chi2_ch4	float32	atrack, xtrack	Methane chi^2 of alpha(1)=f(alpha(2)) fitting	unitless	
chi2_co	float32	atrack, xtrack	Carbon monoxide chi^2 of alpha(1)=f(alpha(2)) fitting	unitless	
chi2_co2	float32	atrack, xtrack	Carbon dioxide chi^2 of alpha(1)=f(alpha(2)) fitting	unitless	
chi2_n2o	float32	atrack, xtrack	Nitrous oxide chi^2 of alpha(1)=f(alpha(2)) fitting	unitless	
chi2_hno3	float32	atrack, xtrack	Nitric acid chi^2 of alpha(1)=f(alpha(2)) fitting	unitless	
chi2_so2	float32	atrack, xtrack	Sulfur dioxide chi^2 of alpha(1)=f(alpha(2)) fitting	unitless	
ispare_2	ushort	atrack, xtrack	Bit flags for rejection of retrieval steps. Details are algorithm-specific.		
bad_phys_ret	ubyte	atrack, xtrack	Flag for bad physical retrieval from bit 1 (value 1) of ispare_2.		
bad_mw_ret	ubyte	atrack, xtrack	Flag for bad microwave retrieval from bits 2 and 4 (values 2 and 8) of ispare_2.		
bad_reg_ret	ubyte	atrack, xtrack	Flag for bad regression retrieval bits 3 and 5 (values 4 and 16) of ispare_2.		
pbest	float32	atrack, xtrack	Maximum value of pressure for which temperature is Quality = 0	Pa	

pgood	float32	atrack, xtrack	Maximum value of pressure for which temperature is Quality = 0 or 1	Pa	
nbest	int16	atrack, xtrack	level index of highest pressure (i.e. lowest altitude) for which Quality = 0. A value of 0 indicates that no part of the profile passes the test.	unitless	
ngood	int16	atrack, xtrack	level index of highest pressure (i.e. lowest altitude) for which Quality = 0 or 1. A value of 0 indicates that no part of the profile passes the test.	unitless	

Table B.1.6 ave_kern Dimensions

Name	Size	Description
air_temp_func_pres	30	Functions used to represent air temperature profile
air_temp_func_pres_bnds	31	Boundaries of functions used to represent air temperature profile
h2o_vap_func_pres	21	Functions used to represent water vapor profile
h2o_vap_func_pres_bnds	22	Boundaries of functions used to represent water vapor profile
o3_func_pres	9	Functions used to represent ozone profile
o3_func_pres_bnds	10	Boundaries of functions used to represent ozone profile
ch4_func_pres	11	Functions used to represent methane profile
ch4_func_pres_bnds	12	Boundaries of functions used to represent methane profile
co_func_pres	9	Functions used to represent carbon monoxide profile
co_func_pres_bnds	10	Boundaries of functions used to represent carbon monoxide profile
co2_func_pres	8	Functions used to represent carbon dioxide profile
co2_func_pres_bnds	9	Boundaries of functions used to represent carbon dioxide profile
hno3_func_pres	8	Functions used to represent nitric acid profile
hno3_func_pres_bnds	9	Boundaries of functions used to represent nitric acid profile

Table B.1.7 ave_kern Variables

Name	Type	Dimensions	Description	Units

air_temp_ave_kern	float32	atrack, xtrack, air_temp_func_pres, air_temp_func_pres	Averaging kernel for air temperature retrieval	
air_temp_func_pres	float32	air_temp_func_pres	Static mean pressures for each vertical basis function used to represent the air temperature profile.	Pa
air_temp_func_last_indx	int16	atrack, xtrack	Last valid index for all quantities with dimension air_temp_func_pres for a given profile. Any further basis functions would be cut off by the surface. Zero when the entire ave_kern matrix is invalid.	
air_temp_func_indxs	int16	air_temp_func_pres_bnds	Pressure indexes defining the trapezoidal basis functions for the air temperature profile	
air_temp_func_htop	int16		Flag if the top air_temperature trapezoidal basis function has value of 1/2 or 1 at TOA.	
air_temp_func_hbot	int16		Flag if the bottom air_temperature trapezoidal basis function has value of 1/2 or 1 at 110000 Pa.	
h2o_vap_ave_kern	float32	atrack, xtrack, h2o_vap_func_pres, h2o_vap_func_pres	Averaging kernel for water vapor retrieval	
h2o_vap_func_pres	float32	h2o_vap_func_pres	Static mean pressures for each vertical basis function used to represent the water vapor profile.	Pa
h2o_vap_func_last_indx	int16	atrack, xtrack	Last valid index for all quantities with dimension h2o_vap_func_pres for a given profile. Any further basis functions would be cut off by the surface. Zero when the entire ave_kern matrix is invalid.	
h2o_vap_func_indxs	int16	h2o_vap_func_pres_bnds	Pressure indexes defining the trapezoidal basis functions for the water vapor profile	
h2o_vap_func_htop	int16		Flag if the top water vapor trapezoidal basis function has value of 1/2 or 1 at TOA.	
h2o_vap_func_hbot	int16		Flag if the bottom water_vapor trapezoidal basis function has value of 1/2 or 1 at 110000 Pa.	
ch4_ave_kern	float32	atrack, xtrack, ch4_func_pres, ch4_func_pres	Averaging kernel for methane retrieval	
ch4_func_pres	float32	ch4_func_pres	Static mean pressures for each vertical basis function used to represent the methane profile.	Pa

ch4_func_last_indx	int16	atrack, xtrack	Last valid index for all quantities with dimension ch4_func_pres for a given profile. Any further basis functions would be cut off by the surface. Zero when the entire ave_kern matrix is invalid.	
ch4_func_indxs	int16	ch4_func_pres_bnds	Pressure indexes defining the trapezoidal basis functions for the methane profile	
ch4_func_htop	int16		Flag if the top methane trapezoidal basis function has value of 1/2 or 1 at TOA.	
ch4_func_hbot	int16		Flag if the bottom methane trapezoidal basis function has value of 1/2 or 1 at 110000 Pa.	
co_ave_kern	float32	atrack, xtrack, co_func_pres, co_func_pres	Averaging kernel for carbon monoxide retrieval	
co_func_pres	float32	co_func_pres	Static mean pressures for each vertical basis function used to represent the carbon monoxide profile.	Pa
co_func_last_indx	int16	atrack, xtrack	Last valid index for all quantities with dimension co_func_pres for a given profile. Any further basis functions would be cut off by the surface. Zero when the entire ave_kern matrix is invalid.	
co_func_indxs	int16	co_func_pres_bnds	Pressure indexes defining the trapezoidal basis functions for the carbon monoxide profile	
co_func_htop	int16		Flag if the top carbon monoxide trapezoidal basis function has value of 1/2 or 1 at TOA.	
co_func_hbot	int16		Flag if the bottom carbon monoxide trapezoidal basis function has value of 1/2 or 1 at 110000 Pa.	
co2_ave_kern	float32	atrack, xtrack, co2_func_pres, co2_func_pres	Averaging kernel for carbon dioxide retrieval	
co2_func_pres	float32	co2_func_pres	Static mean pressures for each vertical basis function used to represent the carbon dioxide profile.	Pa
co2_func_last_indx	int16	atrack, xtrack	Last valid index for all quantities with dimension co2_func_pres for a given profile. Any further basis functions would be cut off by the surface. Zero when the entire ave_kern matrix is invalid.	
co2_func_indxs	int16	co2_func_pres_bnds	Pressure indexes defining the trapezoidal basis functions for the carbon dioxide profile	
co2_func_htop	int16		Flag if the top carbon dioxide trapezoidal basis function has value of 1/2 or 1 at TOA.	
co2_func_hbot	int16		Flag if the bottom carbon dioxide trapezoidal basis function has value of 1/2 or 1 at 110000 Pa.	

o3_ave_kern	float32	atrack, xtrack, o3_func_pres, o3_func_pres	Averaging kernel for ozone retrieval	
o3_func_pres	float32	o3_func_pres	Static mean pressures for each vertical basis function used to represent the ozone profile.	Pa
o3_func_last_indx	int16	atrack, xtrack	Last valid index for all quantities with dimension o3_func_pres for a given profile. Any further basis functions would be cut off by the surface. Zero when the entire ave_kern matrix is invalid.	
o3_func_indxs	int16	o3_func_pres_bnds	Pressure indexes defining the trapezoidal basis functions for the ozone profile	
o3_func_htop	int16		Flag if the top ozone trapezoidal basis function has value of 1/2 or 1 at TOA.	
o3_func_hbot	int16		Flag if the bottom ozone trapezoidal basis function has value of 1/2 or 1 at 110000 Pa.	
hno3_ave_kern	float32	atrack, xtrack, hno3_func_pres, hno3_func_pres	Averaging kernel for nitric acid retrieval	
hno3_func_pres	float32	hno3_func_pres	Static mean pressures for each vertical basis function used to represent the nitric acid profile.	Pa
hno3_func_last_indx	int16	atrack, xtrack	Last valid index for all quantities with dimension hno3_func_pres for a given profile. Any further basis functions would be cut off by the surface. Zero when the entire ave_kern matrix is invalid.	
hno3_func_indxs	int16	hno3_func_pres_bnds	Pressure indexes defining the trapezoidal basis functions for the nitric acid profile	
hno3_func_htop	int16		Flag if the top nitric acid trapezoidal basis function has value of 1/2 or 1 at TOA.	
hno3_func_hbot	int16		Flag if the bottom nitric acid trapezoidal basis function has value of 1/2 or 1 at 110000 Pa.	

Table B.1.8 mol_lay Variables

Name	Type	Dimensions	Description	Units	Ancillary Variables
h2o_vap_mol_lay	float32	atrack, xtrack, air_pres_lay	Water vapor layer total on 100 layers	molecules / m2	err, qc
o3_mol_lay	float32	atrack, xtrack, air_pres_lay	Ozone layer total on 100 layers	molecules / m2	err, qc

co_mol_lay	float32	atrack, xtrack, air_pres_lay	Carbon monoxide layer total on 100 layers	molecules / m2	err, qc
ch4_mol_lay	float32	atrack, xtrack, air_pres_lay	Methane layer total on 100 layers	molecules / m2	err, qc
n2o_mol_lay	float32	atrack, xtrack, air_pres_lay	nitrous oxide layer total on 100 layers	molecules / m2	err, qc
hno3_mol_lay	float32	atrack, xtrack, air_pres_lay	nitric acid layer total on 100 layers	molecules / m2	err, qc
so2_mol_lay	float32	atrack, xtrack, air_pres_lay	sulfur dioxide layer total on 100 layers	molecules / m2	err, qc

Table B.1.9 mw Variables

Name	Type	Dimensions	Description	Units	Ancillary Variables
mw_air_temp	float32	atrack, xtrack, air_pres	air temperature profile from the MW-only step	Kelvin	err, qc
mw_surf_air_temp	float32	atrack, xtrack	Near-surface air temperature (~2 meters above surface) from the MW-only step	Kelvin	err, qc
mw_surf_temp	float32	atrack, xtrack	Radiative temperature of the surface from the MW-only step	Kelvin	err, qc
mw_surf_mw_emis	float32	atrack, xtrack, surf_freq_mw	Microwave surface emissivity from the MW-only retrieval step	unitless	err, qc
mw_h2o_vap_tot	float32	atrack, xtrack	Total precipitable water vapor from the MW-only step	kg / m2	err, qc
mw_h2o_vap_mol_lay	float32	atrack, xtrack, air_pres_lay	Water vapor layer total from the MW-only step	molecules / m2	err, qc
mw_spec_hum	float32	atrack, xtrack, air_pres_h2o	mass fraction of water vapor in moist air from the MW-Only step	unitless	err, qc
mw_surf_spec_hum	float32	atrack, xtrack	Near-surface mass fraction of water vapor in moist air from the MW-Only step	unitless	err, qc

B.2 CLIMCAPS Cloud-Cleared Radiance product

This section lists the interface specification for Level 2 CLIMCAPS cloud cleared radiance product for SNPP. The interface specification version is 02.02.05.

There are a small number of differences between the S-NPP / JPSS-1 and the Aqua products in the Global Dimensions and Global Variables. Table B.2.1. shows the differences.

B.2.1 Differences

Group Name	SNPP / JPSS-1	Aqua
Global Dimensions	wnum_lw	wnum
	wnum_mw	
	wnum_sw	
Global Variables	rad_lw	rad
	rad_mw	
	ra_sw	
	cal_qualflag	
	cal_lw_qualflag	
	cal_mw_qualflag	
	nedn_lw	nedn
	nedn_mw	
	nedn_sw	
	wnum_lw	wnum
	wnum_mw	
	wnum_sw	

B.2.2 Global Groups

Path	Description
/	Main science data
/aux_l2	Internal product team data from L2

B.2.3 Global Dimensions

Name	Size	Description
atrack	45	along-track horizontal dimension
xtrack	30	cross-track horizontal dimension
fov	9	Field-of-view dimension
wnum_lw	717	longwave IR channel number
wnum_mw	437	midwave IR channel number (SNPP NSR)
	869	midwave IR channel number (SNPP FSR and JPSS-1)
wnum_sw	163	shortwave IR channel number (SNPP NSR)
	637	shortwave IR channel number (SNPP SFR and JPSS-1)
fov_poly	8	lat_bnds, lon_bnds points defining the polygon bounding an FOV (anticlockwise as viewed from above)
utc_tuple	8	parts of UTC time: year, month, day, hour, minute, second, millisec, microsec
spatial	3	directions: x, y, z for satellite position and velocity
attitude	3	roll, pitch, yaw

B.2.4 Global Attributes

Name	Type	Size	Value	Description
keywords	string	1	EARTH SCIENCE > SPECTRAL/ENGINEERING > INFRARED WAVELENGTHS > INFRARED RADIANCE	A comma-separated list of key words and/or phrases. Keywords may be common words or phrases, terms from a controlled vocabulary (GCMD is often used), or URIs for terms from a controlled vocabulary (see also "keywords_vocabulary" attribute).
Conventions	string	1	CF-1.6\, ACDD-1.3	A comma-separated list of the conventions that are followed by the dataset.
history	string	1		Provides an audit trail for modifications to the original data. This attribute is also in the NetCDF Users Guide: 'This is a character array with a line for each invocation of a program that has modified the dataset. Well-behaved generic netCDF applications should append a line containing: date, time of day, user name, program name and command arguments.' To include a more complete description you can append a reference to an ISO Lineage entity; see NOAA EDM ISO Lineage guidance.
source	string	1	CrIS and ATMS instrument telemetry	The method of production of the original data. If it was model-generated, source should name the model and its version. If it is observational, source should characterize it. This attribute is defined in the CF Conventions. Examples: 'temperature from CTD #1234'; 'world model v.0.1'.
processing_level	string	1	2	A textual description of the processing (or quality control) level of the data.
product_name_type_id	string	1	L2_CLIMCAPS_CCR	Product name as it appears in product_name (L1A, L1B, L2, SNO_AIRS_CrIS)

Name	Type	Size	Value	Description
comment	string	1		Miscellaneous information about the data or methods used to produce it. Can be empty.
acknowledgment	string	1	Support for this research was provided by NASA.	A place to acknowledge various types of support for the project that produced this data.
license	string	1	Limited to Sounder SIPS affiliates	Provide the URL to a standard or specific license, enter "Freely Distributed" or "None", or describe any restrictions to data access and distribution in free text.
standard_name_vocabulary	string	1	CF Standard Name Table v28	The name and version of the controlled vocabulary from which variable standard names are taken. (Values for any standard_name attribute must come from the CF Standard Names vocabulary for the data file or product to comply with CF.) Example: 'CF Standard Name Table v27'.
date_created	string	1	Unassigned	The date on which this version of the data was created. (Modification of values implies a new version, hence this would be assigned the date of the most recent values modification.) Metadata changes are not considered when assigning the date_created. The ISO 8601:2004 extended date format is recommended, as described in the Attribute Content Guidance section.
creator_name	string	1	Unassigned	The name of the person (or other creator type specified by the creator_type attribute) principally responsible for creating this data.
creator_email	string	1	Unassigned	The email address of the person (or other creator type specified by the creator_type attribute) principally responsible for creating this data.

Name	Type	Size	Value	Description
creator_url	string	1	Unassigned	The URL of the person (or other creator type specified by the creator_type attribute) principally responsible for creating this data.
institution	string	1	Unassigned	Processing facility that produced this file
project	string	1	Sounder SIPS	The name of the project(s) principally responsible for originating this data. Multiple projects can be separated by commas, as described under Attribute Content Guidelines. Examples: 'PATMOS-X', 'Extended Continental Shelf Project'.
product_name_project	string	1	SNDR	The name of the project as it appears in the file name. 'SNDR' for all Sounder SIPS products, even AIRS products.
publisher_name	string	1	Unassigned	The name of the person (or other entity specified by the publisher_type attribute) responsible for publishing the data file or product to users, with its current metadata and format.
publisher_email	string	1	Unassigned	The email address of the person (or other entity specified by the publisher_type attribute) responsible for publishing the data file or product to users, with its current metadata and format.
publisher_url	string	1	Unassigned	The URL of the person (or other entity specified by the publisher_type attribute) responsible for publishing the data file or product to users, with its current metadata and format.
geospatial_bounds	string	1		Describes the data's 2D or 3D geospatial extent in OGC's Well-Known Text (WKT) Geometry format (reference the OGC Simple Feature Access (SFA) specification). The meaning and order of values for

Name	Type	Size	Value	Description
				each point's coordinates depends on the coordinate reference system (CRS). The ACDD default is 2D geometry in the EPSG:4326 coordinate reference system. The default may be overridden with geospatial_bounds_crs and geospatial_bounds_vertical_crs (see those attributes). EPSG:4326 coordinate values are latitude (decimal degrees_north) and longitude (decimal degrees_east), in that order. Longitude values in the default case are limited to the (-180, 180) range. Example: 'POLYGON ((40.26 -111.29, 41.26 -111.29, 41.26 -110.29, 40.26 -110.29, 40.26 -111.29))'.
geospatial_bounds_crs	string	1	EPSG:4326	The coordinate reference system (CRS) of the point coordinates in the geospatial_bounds attribute. This CRS may be 2-dimensional or 3-dimensional, but together with geospatial_bounds_vertical_crs, if that attribute is supplied, must match the dimensionality, order, and meaning of point coordinate values in the geospatial_bounds attribute. If geospatial_bounds_vertical_crs is also present then this attribute must only specify a 2D CRS. EPSG CRSs are strongly recommended. If this attribute is not specified, the CRS is assumed to be EPSG:4326. Examples: 'EPSG:4979' (the 3D WGS84 CRS), 'EPSG:4047'.
geospatial_lat_min	float	1	9.9692099683868690e+36f	Describes a simple lower latitude limit; may be part of a 2- or 3-dimensional bounding region. Geospatial_lat_min specifies the southernmost latitude covered by the dataset.
geospatial_lat_max	float	1	9.9692099683868690e+36f	Describes a simple upper latitude limit; may be part of a 2- or 3-dimensional bounding region.

Name	Type	Size	Value	Description
				Geospatial_lat_max specifies the northernmost latitude covered by the dataset.
geospatial_lon_min	float	1	9.9692099683868690e+36f	Describes a simple longitude limit; may be part of a 2- or 3-dimensional bounding region. geospatial_lon_min specifies the westernmost longitude covered by the dataset. See also geospatial_lon_max.
geospatial_lon_max	float	1	9.9692099683868690e+36f	Describes a simple longitude limit; may be part of a 2- or 3-dimensional bounding region. geospatial_lon_max specifies the easternmost longitude covered by the dataset. Cases where geospatial_lon_min is greater than geospatial_lon_max indicate the bounding box extends from geospatial_lon_max, through the longitude range discontinuity meridian (either the antimeridian for -180:180 values, or Prime Meridian for 0:360 values), to geospatial_lon_min; for example, geospatial_lon_min=170 and geospatial_lon_max=-175 incorporates 15 degrees of longitude (ranges 170 to 180 and -180 to -175).
time_coverage_start	string	1		Nominal start time. Describes the time of the first data point in the data set. Use the ISO 8601:2004 date format, preferably the extended format as recommended in the Attribute Content Guidance section.
time_of_first_valid_obs	string	1		Describes the time of the first valid data point in the data set. Use the ISO 8601:2004 date extended format.
time_coverage_mid	string	1		Describes the midpoint between the nominal start and end times. Use the ISO 8601:2004 date format,

Name	Type	Size	Value	Description
				preferably the extended format as recommended in the Attribute Content Guidance section.
time_coverage_end	string	1		Nominal end time. Describes the time of the last data point in the data set. Use ISO 8601:2004 date format, preferably the extended format as recommended in the Attribute Content Guidance section.
time_of_last_valid_obs	string	1		Describes the time of the last valid data point in the data set. Use the ISO 8601:2004 date extended format.
time_coverage_duration	string	1	P0000-00-00T00:06:00	Describes the duration of the data set. Use ISO 8601:2004 duration format, preferably the extended format as recommended in the Attribute Content Guidance section.
product_name_duration	string	1	m06	Product duration as it appears in product_name (m06 means six minutes)
creator_type	string	1	institution	Specifies type of creator with one of the following: 'person', 'group', 'institution', or 'position'. If this attribute is not specified, the creator is assumed to be a person.
creator_institution	string	1	Jet Propulsion Laboratory -- California Institute of Technology	The institution of the creator; should uniquely identify the creator's institution. This attribute's value should be specified even if it matches the value of publisher_institution, or if creator_type is institution.
product_version	string	1	v02.28.02	Version identifier of the data file or product as assigned by the data creator. For example, a new algorithm or methodology could result in a new product_version.

Name	Type	Size	Value	Description
keywords_vocabulary	string	1	GCMD:GCMD Keywords	If you are using a controlled vocabulary for the words/phrases in your "keywords" attribute, this is the unique name or identifier of the vocabulary from which keywords are taken. If more than one keyword vocabulary is used, each may be presented with a prefix and a following comma, so that keywords may optionally be prefixed with the controlled vocabulary key. Example: 'GCMD:GCMD Keywords, CF:NetCDF COARDS Climate and Forecast Standard Names'.
platform	string	1	SUOMI-NPP > Suomi National Polar-orbiting Partnership	Name of the platform(s) that supported the sensor data used to create this data set or product. Platforms can be of any type, including satellite, ship, station, aircraft or other. Indicate controlled vocabulary used in platform_vocabulary.
platform_vocabulary	string	1	GCMD:GCMD Keywords	Controlled vocabulary for the names used in the "platform" attribute.
product_name_platform	string	1	SNPP	Platform name as it appears in product_name
instrument	string	1	CRIMSS > Cross-track Infrared and Advanced Technology Microwave Sounders\, CrIS > Cross-track Infrared Sounder\, ATMS > Advanced Technology Microwave Sounder	Name of the contributing instrument(s) or sensor(s) used to create this data set or product. Indicate controlled vocabulary used in instrument_vocabulary.
instrument_vocabulary	string	1	GCMD:GCMD Keywords	Controlled vocabulary for the names used in the "instrument" attribute.
product_name_instr	string	1	CRIMSS	Instrument name as it appears in product_name
product_name	string	1		Canonical fully qualified product name (official file name)

Name	Type	Size	Value	Description
product_name_variant	string	1	std	Processing variant identifier as it appears in product_name. 'std' (shorthand for 'standard') is to be the default and should be what is seen in all public products.
product_name_version	string	1	vxx_xx_xx	Version number as it appears in product_name (v01_00_00)
product_name_producer	string	1	T	Production facility as it appears in product_name (single character) 'T' is the default, for unofficial local test products
product_name_timestamp	string	1	yymmddhhmmss	Processing timestamp as it appears in product_name (yymmddhhmmss)
product_name_extension	string	1	nc	File extension as it appears in product_name (typically nc)
granule_number	ushort	1		granule number of day (1-240)
product_name_granule_number	string	1	g000	zero-padded string for granule number of day (g001-g240)
gran_id	string	1	yyyymmddThhmm	Unique granule identifier yyyymmddThhmm of granule start, including year, month, day, hour, and minute of granule start time
geospatial_lat_mid	float	1	9.9692099683868690e+36f	granule center latitude
geospatial_lon_mid	float	1	9.9692099683868690e+36f	granule center longitude
featureType	string	1	point	structure of data in file
data_structure	string	1	swath	a character string indicating the internal organization of the data with currently allowed values of 'grid',

Name	Type	Size	Value	Description
				'station', 'trajectory', or 'swath'. The 'structure' here generally describes the horizontal structure and in all cases data may also be functions, for example, of a vertical coordinate and/or time. (If using CMOR pass this in a call to cmor_set_cur_dataset_attribute.)
cdm_data_type	string	1	Swath	The data type, as derived from Unidata's Common Data Model Scientific Data types and understood by THREDDS. (This is a THREDDS "dataType", and is different from the CF NetCDF attribute 'featureType', which indicates a Discrete Sampling Geometry file in CF.)
id	string	1	Unassigned	An identifier for the data set, provided by and unique within its naming authority. The combination of the "naming authority" and the "id" should be globally unique, but the id can be globally unique by itself also. IDs can be URLs, URNs, DOIs, meaningful text strings, a local key, or any other unique string of characters. The id should not include white space characters.
naming_authority	string	1	Unassigned	The organization that provides the initial id (see above) for the dataset. The naming authority should be uniquely specified by this attribute. We recommend using reverse-DNS naming for the naming authority; URIs are also acceptable. Example: 'edu.ucar.unidata'.
identifier_product_doi	string	1	Unassigned	digital signature
identifier_product_doi_authority	string	1	Unassigned	digital signature source

Name	Type	Size	Value	Description
algorithm_version	string	1		The version of the algorithm in whatever format is selected by the developers. After the main algorithm name and version, versions from multiple sub-algorithms may be concatenated with semicolon separators. (ex: 'CCAST 4.2; BB emis from MIT 2016-04-01') Must be updated with every delivery that changes numerical results.
production_host	string	1		Identifying information about the host computer for this run. (Output of linux "uname -a" command.)
format_version	string	1	v02.01.06	Format version.
input_file_names	string	1		Semicolon-separated list of names or unique identifiers of files that were used to make this product. There will always be one space after each semicolon. There is no final semicolon.
input_file_types	string	1		Semicolon-separated list of tags giving the role of each input file in input_file_names. There will always be one space after each semicolon. There is no final semicolon.
input_file_dates	string	1		Semicolon-separated list of creation dates for each input file in input_file_names. There will always be one space after each semicolon. There is no final semicolon.
orbitDirection	string	1		Orbit is ascending and/or descending. Values are "Ascending" or "Descending" if the entire granule fits that description. "NorthPole" and "SouthPole" are used for polar-crossing granules. "NA" is used when a determination cannot be made.

Name	Type	Size	Value	Description
day_night_flag	string	1		Data is day or night. "Day" means subsatellite point for all valid scans has solar zenith angle less than 90 degrees. "Night" means subsatellite point for all valid scans has solar zenith angle greater than 90 degrees. "Both" means the dataset contains valid observations with solar zenith angle above and below 90 degrees. "NA" means a value could not be determined.
AutomaticQualityFlag	string	1	Missing	"Passed": the granule contains a non-degraded calibrated brightness temperature, radiance, or retrieved value for at least one value in a geolocated FOV; "Suspect": the granule does not qualify as "Passed" but contains a (possibly degraded) calibrated or retrieved value (possibly without associated geolocation); "Failed": the granule contains no calibrated or retrieved values.
qa_pct_data_missing	float	1		Percentage of expected observations that are missing.
qa_pct_data_geo	float	1		Percentage of expected observations that are successfully geolocated.
qa_pct_data_sci_mode	float	1		Percentage of expected observations that were taken while the instrument was in science mode and are successfully geolocated.
qa_no_data	string	1	TRUE	A simple indicator of whether this is an "empty" granule with no data from the instrument. "TRUE" or "FALSE".
title	string	1	Level-2 CLIMCAPS SNPP CrIMSS Clear Radiances	a succinct description of what is in the dataset. (= ECS long name)
summary	string	1	The Level-2 CLIMCAPS cloud-cleared product includes infrared	A paragraph describing the dataset, analogous to an abstract for a paper.

Name	Type	Size	Value	Description
			radiances adjusted to simulate clear-sky conditions.	
shortname	string	1	SNDRSNIML2CCPCCR	ECS Short Name
product_group	string	1	l2_crimss_cc	The group name to be used for this product when it is collected in a multi-group file type, like SNO or calsub
metadata_link	string	1	Unassigned	A URL that gives the location of more complete metadata. A persistent URL is recommended for this attribute.
references	string	1		ATDB and design documents describing processing algorithms. Can be empty.
contributor_name	string	1	Christopher D. Barnet\, STC; L. Larrabee Strow\, UMBC; Philip W. Rosenkranz\, MIT	The names of any individuals or institutions that contributed to the creation of this data.
contributor_role	string	1	Retrieval PI; Forward Model PI; Microwave PI	The roles of any individuals or institutions that contributed to the creation of this data.

B.2.5 Global Variables

Name	Type	Dimensions	Description	Units	Ancillary Variables
obs_id	string	atrack, xtrack	unique earth view observation identifier: yyyymmddThhmm.aaExx. Includes gran_id plus 2-digit along-track index (01-45) and 2-digit cross-track index (01-30).		

fov_obs_id	string	atrack, xtrack, fov	unique earth view observation identifier for FOV: yyyymmddThhmm.aaExx.f . Includes gran_id plus 2-digit along-track index (01-45), 2-digit cross-track index (01-30), and 1-digit FOV number (1-9).		
obs_time_tai93	double	atrack, xtrack	earth view observation midtime for each FOV	seconds since 1993-01-01 00:00	bnds
obs_time_utc	uint16	atrack, xtrack, utc_tuple	UTC earth view observation time as an array of integers: year, month, day, hour, minute, second, millisec, microsec		
lat	float	atrack, xtrack	latitude of FOR center	degrees_north	bnds
lat_geoid	float	atrack, xtrack	latitude of FOR center on the geoid (without terrain correction)	degrees_north	
fov_lat	float	atrack, xtrack, fov	latitude of FOV center	degrees_north	bnds
lon	float	atrack, xtrack	longitude of FOR center	degrees_east	bnds
lon_geoid	float	atrack, xtrack	longitude of FOR center on the geoid (without terrain correction)	degrees_east	
fov_lon	float	atrack, xtrack, fov	longitude of FOV center	degrees_east	bnds
land_frac	float	atrack, xtrack	land fraction over the FOR	unitless	
fov_land_frac	float	atrack, xtrack, fov	land fraction over the FOV	unitless	
surf_alt	float	atrack, xtrack	mean surface altitude wrt earth model over the FOR	m	
fov_surf_alt	float	atrack, xtrack, fov	mean surface altitude wrt earth model over the FOV	m	

surf_alt_sdev	float	atrack, xtrack	standard deviation of surface altitude within the FOR	m	
fov_surf_alt_sdev	float	atrack, xtrack, fov	standard deviation of surface altitude within the FOV	m	
sun_glint_lat	float	atrack	sun glint spot latitude at scan_mid_time. Fill for night observations.	degrees_north	
sun_glint_lon	float	atrack	sun glint spot longitude at scan_mid_time. Fill for night observations.	degrees_east	
sol_zen	float	atrack, xtrack	solar zenith angle at the center of the spot	degree	
sol_azi	float	atrack, xtrack	solar azimuth angle at the center of the spot (clockwise from North)	degree	
sun_glint_dist	float	atrack, xtrack	distance of sun glint spot to the center of the spot. Fill for night observations.	m	
view_ang	float	atrack, xtrack	off nadir pointing angle	degree	
sat_zen	float	atrack, xtrack	satellite zenith angle at the center of the spot	degree	
sat_azi	float	atrack, xtrack	satellite azimuth angle at the center of the spot (clockwise from North)	degree	
sat_range	float	atrack, xtrack	line of sight distance between satellite and spot center	m	
asc_flag	ubyte	atrack	ascending orbit flag: 1 if ascending, 0 descending		
subsat_lat	float	atrack	sub-satellite latitude at scan_mid_time	degrees_north	
subsat_lon	float	atrack	sub-satellite longitude at scan_mid_time	degrees_east	
scan_mid_time	double	atrack	TAI93 at middle of earth scene scans	seconds since 1993-01-01 00:00	

sat_alt	float	atrack	satellite altitude with respect to earth model at scan_mid_time	m	
sat_pos	float	atrack, spatial	satellite ECR position at scan_mid_time	m	
sat_vel	float	atrack, spatial	satellite ECR velocity at scan_mid_time	m s-1	
sat_att	float	atrack, attitude	satellite attitude at scan_mid_time. An orthogonal triad. First element is angle about the +x (roll) ORB axis. +x axis is positively oriented in the direction of orbital flight. Second element is angle about +y (pitch) ORB axis. +y axis is oriented normal to the orbit plane with the positive sense opposite to that of the orbit's angular momentum vector H. Third element is angle about +z (yaw) axis. +z axis is positively oriented Earthward parallel to the satellite radius vector R from the spacecraft center of mass to the center of the Earth.	degree	
local_solar_time	float	atrack, xtrack	local apparent solar time in hours from midnight	hours	
mean_anom_wrt_equat	float	atrack	spacecraft mean anomaly measured with respect to the ascending node	degree	
sat_sol_zen	float	atrack	solar zenith angle at the satellite	degree	
sat_sol_azi	float	atrack	solar azimuth angle at the satellite (clockwise from North)	degree	
asc_node_lon	float		Longitude of the last ascending node of spacecraft orbit before time_coverage_end.	degrees_east	
asc_node_tai93	double		TAI93 time of the last ascending node of spacecraft orbit before time_coverage_end.	seconds since 1993-01-01 00:00	
asc_node_local_solar_time	float		local apparent solar time at the last ascending node before time_coverage_end in hours from midnight	hours	

solar_beta_angle	float		Beta angle for the spacecraft orbit, determining the percentage of the orbit that the spacecraft is in direct sunlight.	degree	
attitude_lbl	string	attitude	list of rotational directions (roll, pitch, yaw)		
spatial_lbl	string	spatial	list of spatial directions (X, Y, Z)		
utc_tuple_lbl	string	utc_tuple	names of the elements of UTC when it is expressed as an array of integers year,month,day,hour,minute,second,millisecond,microsecond		
rad_lw	float32	atrack, xtrack, wnum_lw	longwave clear spectral radiance	mW/(m2 sr cm-1)	err, qc
rad_mw	float32	atrack, xtrack, wnum_mw	midwave clear spectral radiance	mW/(m2 sr cm-1)	err, qc
rad_sw	float32	atrack, xtrack, wnum_sw	shortwave clear spectral radiance	mW/(m2 sr cm-1)	err, qc
cal_qualflag	int32	atrack, xtrack, fov	per-observation L1B product quality		
cal_lw_qualflag	int32	atrack, xtrack, fov	per-observation L1B LW product quality		
cal_mw_qualflag	int32	atrack, xtrack, fov	per-observation L1B MW product quality		
cal_sw_qualflag	int32	atrack, xtrack, fov	per-observation L1B SW product quality		
nedn_lw	float32	fov, wnum_lw	longwave noise equivalent differential radiance	mW/(m2 sr cm-1)	
nedn_mw	float32	fov, wnum_mw	midwave noise equivalent differential radiance	mW/(m2 sr cm-1)	

nedn_sw	float32	fov, wnum_sw	shortwave noise equivalent differential radiance	mW/(m2 sr cm-1)	
wnum_lw	float64	wnum_lw	longwave wavenumber	cm-1	
wnum_mw	float64	wnum_mw	midwave wavenumber	cm-1	
wnum_sw	float64	wnum_sw	shortwave wavenumber	cm-1	

B.2.6 aux_l2 Variables

Name	Type	Dimensions	Description	Units	Ancillary Variables
idprof	string	atrack, xtrack	profile ID		
etarej	float32	atrack, xtrack	cloud clearing residual used f/ rej at iteration = ieta_rej	unitless	
cldfrc_tot	float32	atrack, xtrack	Total cloud fraction over FOR	unitless	
cldfrc_500	float32	atrack, xtrack	Total cloud fraction over FOR below 500 hPa	unitless	
ampl_eta	float32	atrack, xtrack	cloud clearing noise amplification factor	unitless	
ir_x	float32	atrack, xtrack	RMS(rad(IR.ret)-radobs()) for AMSU channels	unitless	
bt2	float32	atrack, xtrack	RMS(T(p) f/IR.ret - T(p) f/ AMSU.ret)	unitless	
qualsurf	float32	atrack, xtrack	qualsurf		
qualtemp	float32	atrack, xtrack	qualtemp		
softcode	float32	atrack, xtrack	software rejection code		
aeff_1	float32	atrack, xtrack	A_eff(1st eta step)	unitless	

Name	Type	Dimensions	Description	Units	Ancillary Variables
aeff_end	float32	atrack, xtrack	A_eff(last eta step)	unitless	
a0_cloud	float32	atrack, xtrack	intercept of alpha(1)=f(alpha(2)) fitting	unitless	
totliqwat	float32	atrack, xtrack	total liquid water (MW)	unitless	
fov_weight	float32	atrack, xtrack, fov	Contribution weighting of FOV within FOR for cloud cleared radiances. Can be negative.	unitless	
chi2_temp	float32	atrack, xtrack	Temperature profile chi^2 of alpha(1)=f(alpha(2)) fitting	unitless	
chi2_h2o	float32	atrack, xtrack	Water vapor chi^2 of alpha(1)=f(alpha(2)) fitting	unitless	
chi2_o3	float32	atrack, xtrack	Ozone chi^2 of alpha(1)=f(alpha(2)) fitting	unitless	
chi2_ch4	float32	atrack, xtrack	Methane chi^2 of alpha(1)=f(alpha(2)) fitting	unitless	
chi2_co	float32	atrack, xtrack	Carbon monoxide chi^2 of alpha(1)=f(alpha(2)) fitting	unitless	
chi2_co2	float32	atrack, xtrack	Carbon dioxide chi^2 of alpha(1)=f(alpha(2)) fitting	unitless	
chi2_n2o	float32	atrack, xtrack	Nitrous oxide chi^2 of alpha(1)=f(alpha(2)) fitting	unitless	
chi2_hno3	float32	atrack, xtrack	Nitric acid chi^2 of alpha(1)=f(alpha(2)) fitting	unitless	
chi2_so2	float32	atrack, xtrack	Sulfur dioxide chi^2 of alpha(1)=f(alpha(2)) fitting	unitless	